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A STUDY OF THE BIOLOGY OF THE CUTTHROAT TROUT IN THE SHEEP RIVER WITH SPECIAL REFERENCE TO GORGE CREEK

by

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A Thesis Submitted in Candidacy for the Degree

of

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The undersigned hereby certify that they have read and recommend to the Committee on Graduate Studies for acceptance a thesis entitled "A Study of the Biology of the Cutthroat Trout in the Sheep River with Special Reference to Gorge Creek" submitted by Alexander Andrekson, B.Sc., in partial fulfilment of the requirements for the degree of Master of Science.

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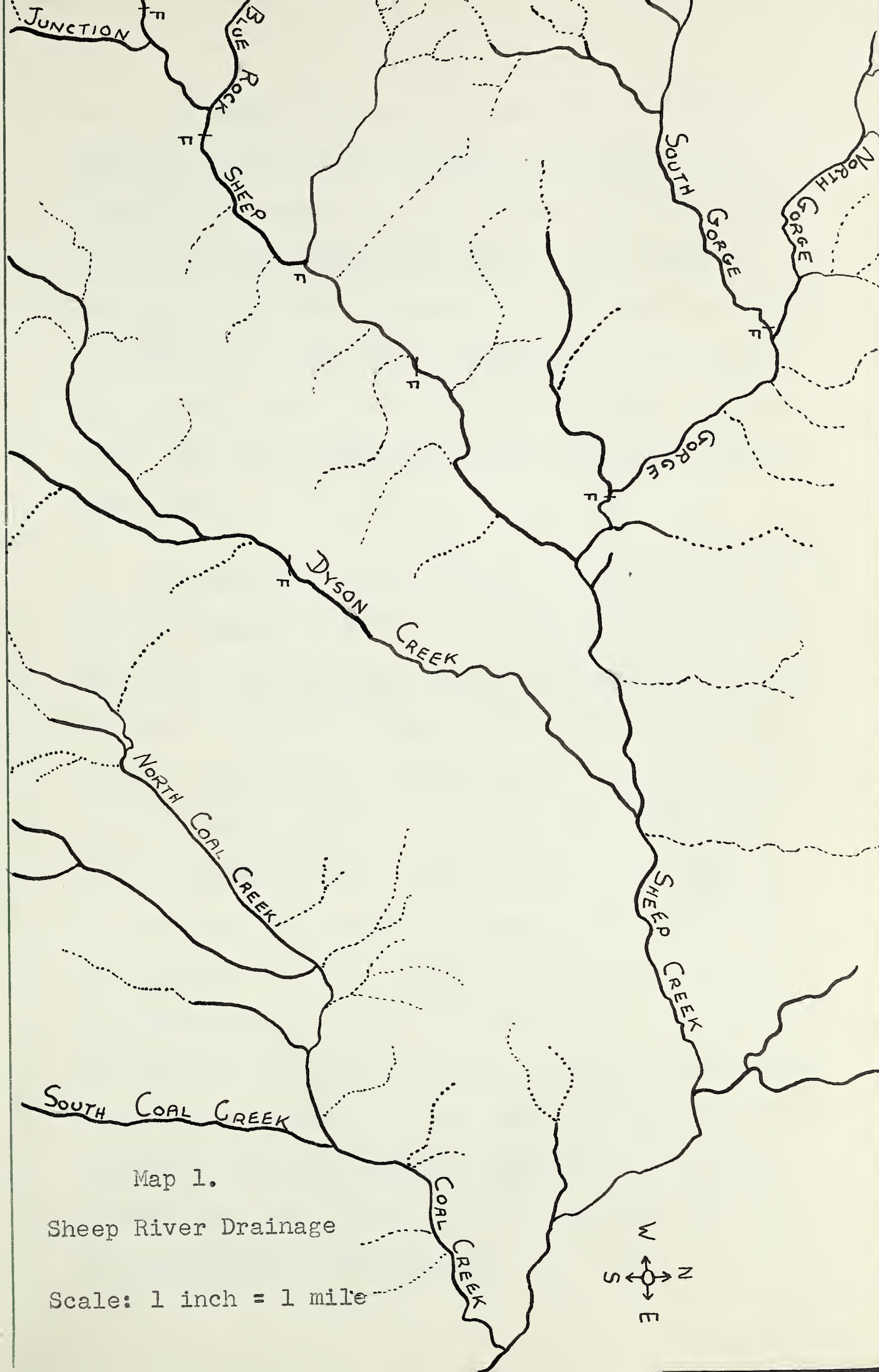
INTRODUCTION

The streams of the East Slope of the Rocky Mountains provide one of the few remaining regions where trout may live naturally. Cool, unpolluted water, absolutely necessary for trout, is becoming a scarcity in North America. These east slope streams, therefore, are of unusual interest to the student of fish, as here trout may be studied under circumstances practically unchanged from those that prevailed before this country was settled.

Only one species of true trout is native to these streams. It is the cutthroat trout, _Salmo clarkii (Richardson)_. Rainbow trout, native to the western slopes of the Rockies, and brown trout, from Europe, have been introduced during the last thirty years. The influence that these "foreigners" may have on the native trout can only be guessed. But their introduction makes it important that the habits and nature of the native trout be determined before they are too much affected.

A region of the east slope where the introduced trout have made little headway is the upper part of the Sheep River drainage (see map 1). A preliminary



Map 1.

Sheep River Drainage

Scale: 1 inch = 1 mile

study has shown that Gorge Creek, part of this region, appears to be a typical cutthroat trout stream. Consequently, Gorge Creek was selected for a study of the abundance, growth rate, feeding habits and seasonal movements of the cutthroat trout. Portions of the main Sheep River and neighbouring tributaries, Blue Rock Creek, Coal Creek, Junction Creek and Dyson Creek were also studied to provide comparisons.

In addition to this general study of the biology of the cutthroat trout, a taxonomic study was made. The trout fishermen are largely unfamiliar with the methods of distinguishing cutthroat and rainbow trout. Most anglers report their catches as rainbows although provincial surveys have shown that mostly cutthroats are being caught. Therefore it is necessary to formulate a clear cut description of the native trout. There is involved here the practical matter of the fish hatchery. The anglers, who believe they are catching rainbow trout, demand that this species be reared and distributed in the streams. It seems probable, however, that these streams are really cutthroat streams and the rainbows may have deleterious effects.

Although the prime purpose of the investigation was a study of the biology of the cutthroat trout, it was also necessary to make a study of the effects of various environmental factors. Therefore, the investigation included an estimate of the biotic potential of the East Slope streams, using the Sheep River drainage in general and Gorge Creek in particular as the experimental area.

In the account which follows, Gorge Creek and the other streams studied are first described. Then the taxonomic status and biology of the cutthroat trout is discussed.

DESCRIPTION OF GORGE CREEK

General Description

Gorge Creek arises in two main branches, South Fork and North Fork. The South Fork begins on the northwest slope of Blue Rock Mountain at a height of 6,000 feet. The North Fork rises at the same altitude on the northeast slopes of Ware Mountain.

Each of the forks of Gorge Creek runs about four water miles to the point where they unite to form the main creek. From this junction, the creek continues another four miles to join the Sheep River.

The average drop in level is about 150 feet per mile. In May, when water is plentiful, this gradient produces a water velocity of approximately seven miles per hour. By mid-summer, the rate of flow has diminished to one and one-half to two miles per hour.

The South Fork of Gorge Creek is fairly shallow with small rapids, but it also contains some beautiful pools. At places, the stream narrows down to four feet and the water becomes torrential. The cover of the stream up to this point is good, with willow, black birch and the occasional evergreen.

However, though the cover is good, the tributaries of the head waters become muddy after only two hours of rain. The cause of this is that water is shed from the steep shale sides of Ware Mountain. The water becomes less opaque within a few hours of the time it stops raining. The main Gorge Creek gets very muddy if the rain is the full length of the creek. This may be accounted for by the steep

shale banks in its last four miles (from the junction of the South and North Forks) to within 250 yards of where it empties into the Sheep River.

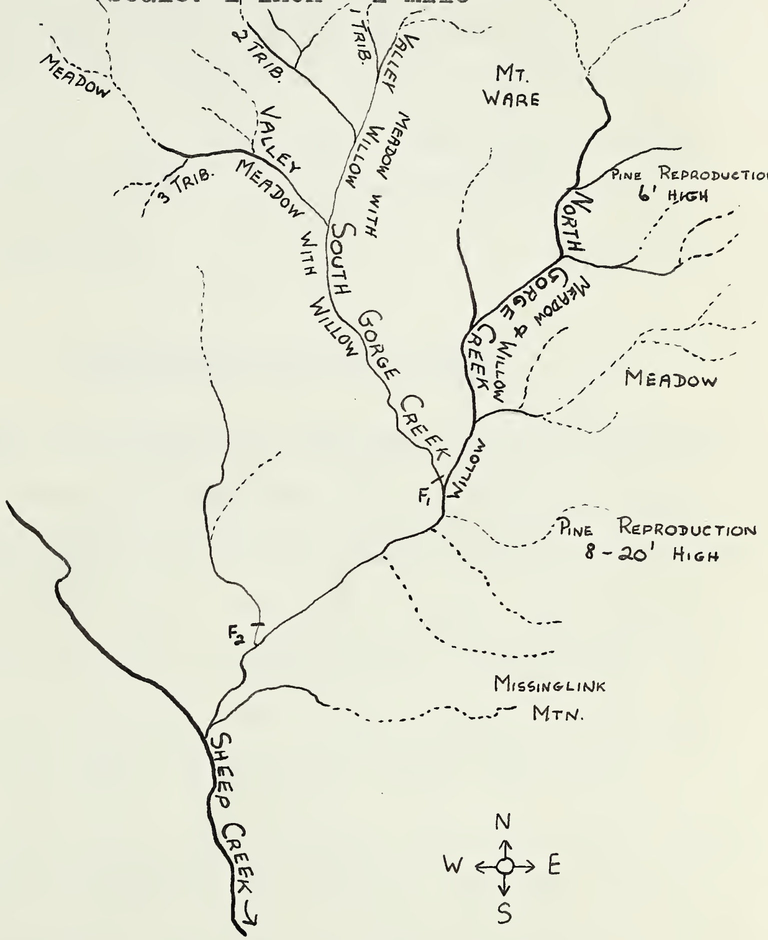
The North Fork of Gorge Creek arises in a terrain that has been burnt over but is now recovering with a pine reproduction six feet fall. This stream, in its lower reaches, is covered mainly with willow and winds gently through meadows. When it rains this stream never gets as turbid as does the South Fork. It joins the South Fork as indicated on map 2 at point F_1. This is a two-tiered falls, which is discussed in greater detail in a later section.

The main Gorge Creek winds through a rocky bed which is enveloped on either side by steep, shale banks which, on the average, are from thirty to fifty feet in height. These abrupt banks keep the sun's rays from striking the major portion of the stream in midday, so even though vegetation is practically non-existent, there is a certain amount of shade. The creek bed itself is very rocky, with some beds of gravel, sand and rubble.

Map 2.

Gorge Creek, its Headwaters, Type of Cover and Terrain Which if Passes Through

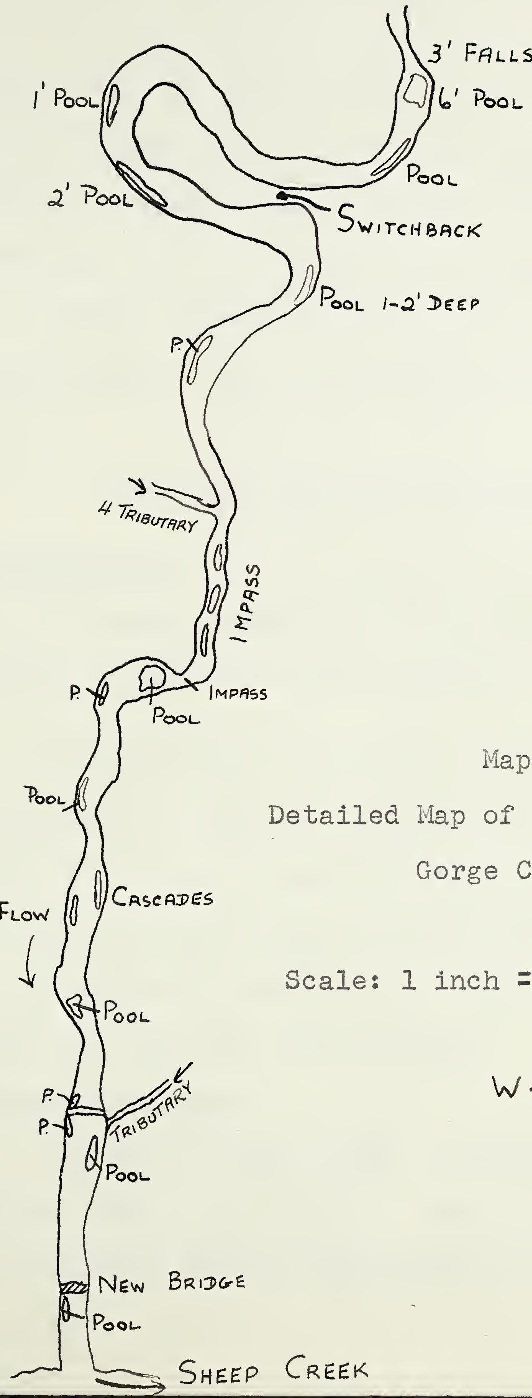
Scale: 1 inch = 1 mile



The stream runs through a narrow gorge, in places only six feet wide, with numerous small falls, none of which appears to be impassable. The average width of the creek is ten to fifteen feet. From map 3 it can be seen that there are eighteen pools in the first mile of stream. Many large boulders augment these pools as rest havens behind which trout can rest.

Tributaries of Gorge Creek

The tributaries of the headwaters of the South Gorge Creek vary from three to eight feet in width and the depth varies from a few inches to pools that are two feet deep. The pools are not too frequent, usually occurring at bends in the stream where the banks are undercut. The cover, which is good, is mainly fir near the mountain itself and shrub willow and black birch further from the steep slopes. The banks themselves are covered with moss, and the greater part of the terrain from the mountain to the main channel of the gorge is grassy meadow with overhanging shrubs. Fish were found in all tributaries of the headwaters.



Map 3.

Detailed Map of Last Mile of Gorge Creek

Scale: 1 inch = 200 yards

Below the falls, marked F_1 on map 2, there are five tributaries which enter main Gorge Creek. Four enter from the north, arising from the slopes of Missing Link Mountain, and winding through meadows before joining the main stream. There is only one tributary from the south which arises in meadows and is a gentle stream throughout its course. No fish were found in the tributaries below the falls.

Physical and Chemical Features

Temperatures:

In Gorge Creek the temperature varied from 40° F. in May to a high of 67° F. in July.

The last week in May the temperature fluctuated between 40° F. and 54° F. This is a daily fluctuation of 14° F. The maximum temperature is reached between 4:00 P.M. and 5:00 P.M. while the minimum is reached after midnight and remains at a minimum till 8:00 A.M. the next morning.

Chemical Factors:

The pH of Gorge Creek, as measured with a Hellige pocket comparator, is 8.1. The pH of the South Fork is 8.2 while that of North Fork is 7.8.

Table 1. The Maximum and Minimum Temperatures Observed at Various Times in Gorge Creek.

Month	Temperatures ° F.	
	Min.	Max.
May 24th-31st	40	54
June	40	56
July	51	67
August	51	67

Bottom Fauna of Gorge Creek

As Gorge Creek was the main stream under observation, fifty bottom samples were taken during the course of the three month period. Samples were obtained from the North and South Forks and the main creek at the localities marked on map 4. The samples were taken with a standard stream bottom sampler. (Davis, 1938). The findings are summarized in Tables 2 to 7.

Map 4.

Location of 50 Bottom Samples Taken From

Gorge Creek

Scale: 1 inch = 1 mile

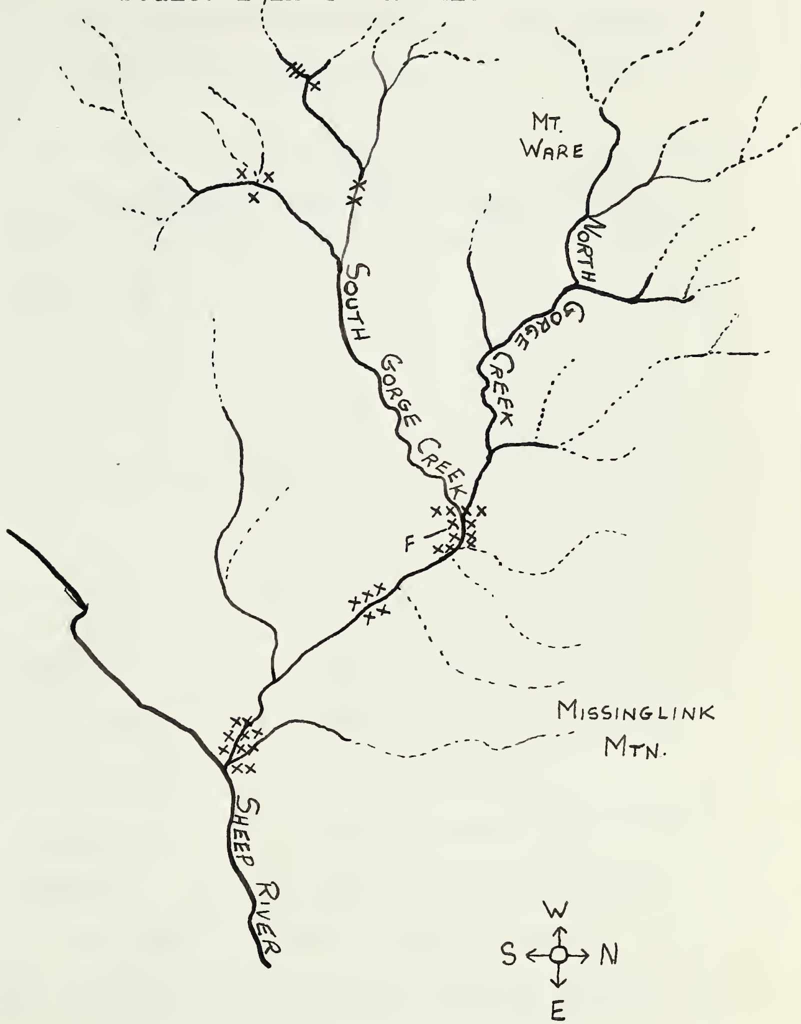


Table 2. An analysis of seven bottom samples from the headwaters of South Gorge Creek. Each sample was taken from one square foot of stream bottom.

No.	Vol. cc.	No. May Ny			No. Stone Ny		Miscell			
		Ba	Ri	Eph	Ac	Ne	Mi	Cra	Be	Ca
1	.15	15	10	-	-	2	-	-	-	7
2	.07	21	15	1	8	-	9	-	1	6
3	.10	40	5	1	34	2	-	-	-	3
4	.10	36	10	4	12	-	6	-	-	1
5	.20	87	30	14	9	7	2	2	-	3
6	.35	5	22	5	9	-	4	2	-	60
7	.25	2	-	1	-	-	-	1	1	77

Key I.

Ba - <u>Baetis</u>

Ri - <u>Rithrogena</u>

Eph - <u>Ephemerella</u>

Ac - <u>Acroneuria</u>

Ne - <u>Nemoura</u>

Mi - Midge larvae

Cra - Cranefly larvae

Be - Beetle

Ca - Caddis fly larvae

Blk - Blackfly larvae

No. May Ny - Number of Mayfly nymphs

No. Stone Ny - Number of Stonefly nymphs

The volume varied from 0.07 to 0.35 cc. per square foot in the headwaters. The average volume was 0.13 cc. per square foot. Mayfly nymphs were the most numerous; stonefly nymphs and caddis larvae were also present in considerable numbers.

Table 3. An analysis of four bottom samples from lower South Gorge Creek. Each sample was taken from one square foot of stream bottom.

No.	Vol. cc.	No May Ny			No Stone Ny		Miscell			
		Ba	Ri	Eph	Ac	Ne	Mi	Blk	Be	Ca
1	.50	44	64	21	26	-	9	-	-	24
2	.10	12	18	1	14	-	5	1	-	10
3	.30	11	25	5	5	3	2	-	1	-
4	.25	2	22	7	14	-	4	-	1	-

See Key I, page 9

The volume varied from 0.10 to 0.50 cc. The average volume was 0.29 cc. per square foot. This quantity is about twice as great as that found in the headwaters.

Table 4. An analysis of four bottom samples from North Gorge Creek. Each sample was taken from one square foot of stream bottom.

No.	Vol. cc.	No May Ny Ba	Ri	Eph	No Stone Ny Ac	Ne	Miscell Mi	Blk	Ca	Cra	Be
1	.70	9	17	5	-	-	11	-	1	1	5
2	.65	23	4	-	28	-	1	1	-	1	8
3	.30	19	-	-	42	2	-	-	1	7	10
4	.30	46	18	2	7	-	4	1	4	-	-
See Key I, page 9											

The volume of samples from North Gorge Creek varied from 0.30 cc. per square foot to 0.70 cc. per square foot. The average volume was 0.49 cc. per square foot. Mayfly nymphs were the most numerous, and of these, Baetis was most abundant. The average volume of the bottom samples from North Gorge is four times that of the headwaters of South Gorge and about two-fifths greater than that of the lower waters of South Gorge. The absence of crane-fly larvae from the lower waters of South Gorge probably accounts for part of the difference.

Table 5. An analysis of ten bottom samples from main Gorge Creek just below the junction of the North and South Forks of Gorge Creek. Each sample was taken from one square foot of stream bottom.

No.	Vol. cc.	No May Ny			No Stone Ny		Miscell				
		Ba	Ri	Eph	Ac	Ne	Ca	Mi	Cra	Be	Blk
1	.02	5	4	-	4	-	-	2	2	1	-
2	.10	3	16	2	-	-	2	10	2	-	-
3	.10	4	13	-	3	3	-	-	2	-	-
4	1.15	22	18	21	13	5	12	7	1	1	-
5	.60	17	44	3	28	5	20	-	-	-	11
6	.30	37	12	3	15	2	2	-	2	1	-
7	1.60	46	34	17	30	3	9	-	1	-	6
8	.15	15	14	1	9	1	2	4	-	-	-
9	.15	43	17	-	15	-	5	-	2	1	-
10	.80	61	70	3	23	4	15	2	1	1	-
Miscellaneous - 1 planaria											
See Key I, page 9											

The volume of separate bottom samples varies from 0.02 cc. to 1.60 cc. which is a very wide fluctuation. The 0.02 cc. sample was taken on a shifting sand bottom, just below a pool. Mayfly nymphs were again in the largest numbers. The average volume was 0.50 cc. per square foot.

Table 6. An analysis of five bottom samples from main Gorge Creek midway between the junction of the North and South Forks and the Sheep River. Each sample was taken from one square foot of the stream bottom.

No.	Vol. cc.	No May Ny			No Stone Ny		Miscell				
		Ba	Ri	Eph	Ac	Ne	Ca	Mi	Cra	Be	Blk
1	.30	6	3	1	27	-	-	-	1	1	-
2	.25	13	7	1	13	2	2	3	-	-	1
3	.20	10	48	3	20	2	1	-	-	1	-
4	.55	5	60	6	28	3	-	5	1	1	-
5	.01	4	-	-	2	-	-	2	-	-	-

See Key I, page 9

The volume of these bottom samples varies from 0.01 cc to 0.55 cc. per square foot. The average volume was 0.26 cc. per square foot. Mayfly nymphs were present in the largest number, followed closely by stonefly nymphs.

Table 7. An analysis of twenty bottom samples from the main Gorge Creek from its mouth upstream two hundred yards. Each sample was taken from one square foot of stream bottom.

No.	Vol. cc.	No May Ny			No Stone Ny		Miscell				
		Ba	Ri	Eph	Ac	Ne	Ca	Mi	Cra	Be	Blk
1	.10	19	-	-	2	4	2	-	-	-	1
2	.11	5	13	7	5	-	-	-	-	-	-
3	.18	8	44	4	12	6	36	2	-	-	-
4	.65	29	102	3	29	16	84	-	2	1	-
5	.55	30	44	10	15	2	9	10	1	-	-
6	.03	1	1	-	2	-	3	-	-	-	-
7	.55	12	48	-	6	2	59	-	-	-	-
8	.40	37	18	1	13	1	7	-	1	-	-
9	.50	57	51	8	27	6	2	-	-	3	2
10	.35	36	35	2	9	4	8	-	-	5	-
11	.25	13	17	-	18	-	13	-	-	-	-
12	.70	36	72	3	20	5	19	-	3	-	2
13	.35	38	34	-	6	5	-	2	5	-	2
14	.22	17	26	-	9	-	1	-	2	1	-
15	.40	19	4	5	19	-	-	1	1	1	-
16	.50	11	17	1	23	-	3	-	1	-	-
17	.50	31	36	5	14	-	6	-	2	3	-
18	.10	14	5	-	19	-	-	3	1	1	-
19	.30	19	29	1	-	1	-	2	8	-	64
20	.60	49	122	-	10	6	2	5	-	-	18
Miscellaneous: 16 planaria, 2 worms											
See Key I, page 9											

In these lower reaches of the Gorge, bottom samples varied in volume from 0.10 cc. per square foot to 0.70 cc. per square foot of bottom. The average volume is 0.37 cc. per square foot. The total volume was made up largely of mayfly nymphs, stonefly nymphs and, to a lesser extent, by caddis fly larvae.

In general, the samples reveal a rather meagre bottom fauna, at least as judged by the standards set up by Davis (1938) for the U. S. Biological Survey. According to these standards, all streams having less than 1 cc. of fauna per square foot are poor. The average fauna of Gorge Creek is 0.35 cc. per square foot.

Samples from the headwaters showed the least fauna, probably because of lower temperatures. Variations in quantity below the headwaters seem too small to be significant.

DESCRIPTION OF OTHER AREAS STUDIED

Sheep River

The Sheep River rises west of Cougar Mountain

at an elevation of 7,000 feet. It runs approximately seventy water miles eastward to enter the Highwood River at an elevation of 3,000 feet. This is an average fall of seventy-five feet per mile. Half of the total descent occurs in the first twelve miles where the gradient is one hundred and sixty-seven feet per mile. This is a steep river gradient, almost torrential. Considerable stretches of the upper Sheep run through narrow gorges; this, combined with stream gradient, makes reaches of very fast water.

The river was examined in the vicinity of Junction Creek, at intervals between Junction and Gorge Creeks, in the vicinity of Gorge Creek, and in the vicinity of Coal Creek.

Upper Sheep:

At Junction Creek the Sheep River is flowing at approximately four miles per hour - very swift. It is also cold - 47° F., and completely lacking in pools or cover. The bottom is a uniform depth of three to four feet and composed of coarse rubble. Just above the mouth of Junction Creek a low dam blocks the channel.

About one and one-half miles below Junction Creek, the current is still four miles per hour. The channel is one hundred feet wide with a few large and several small pools.

In the vicinity of Gorge Creek the stream is braided in channels eighty to ninety feet wide which unite at Gorge Creek to one channel about one hundred and twenty feet wide. At this point the bottom is rubble without pools or bank cover.

From Gorge Creek to Coal Creek the river runs through a deep gorge for about five miles. It is swift, braided and exposed. Pools occur only at turns in the channel, about every two hundred yards. The next mile and a half to Coal Creek sees the Sheep come out of the gorge, widen and become shallower. There are no pools or bank cover. Here the bottom is gravel.

No work was done below the point of entry of Coal Creek into Sheep River.

The average drop in level is about one hundred and fifty feet per mile. In May, when water is

plentiful from the spring runoff, the water level of the Sheep River is at least six feet higher than its normal level. The rate of flow varied from four and one-half miles per hour in July to three and four-tenths miles per hour in August.

The upper Sheep as a whole is very poorly provided with vegetation. Its headwaters have good evergreen growth on either side, but the channel is so deep that shade to the stream is non-existent. Below Junction Creek, vegetation on its banks is negligible.

Temperature varied from 40° to 50° F. throughout the summer.

The pH of Sheep River is 8.1 which is exactly the same as that of Gorge Creek.

Bottom Fauna

Seven bottom samples were taken, two from above Junction Creek and five from below Gorge Creek. The analyses of these is shown in Tables 8 and 9.

Table 8. An analysis of two bottom samples from the Sheep River taken above the entrance of Junction Creek. Each sample was taken from one square foot of stream bottom.

No.	Vol. cc.	No May Ny			No Stone Ny		Miscell				
		Ba	Ri	Eph	Ac	Ne	Ca	Mi	Cra	Be	Blk
1	.21	4	36	1	7	29	16	6	-	-	-
2	.28	11	55	-	2	1	1	6	-	-	19
See Key I, page 9											

Sample 1 was taken in late July and 2 in mid-August. The presence of blackfly larvae in the later sample probably accounts for the difference in volume of the two samples. The mayfly nymphs were three times as numerous as stonefly nymphs.

Table 9. An analysis of five bottom samples from Sheep River taken below Gorge Creek. Each sample was taken from one square foot of stream bottom.

No.	Vol. cc.	No May Ny			No Stone Ny		Miscell				
		Ba	Ri	Eph	Ac	Ne	Ca	Mi	Cra	Be	Blk
1	.20	18	58	-	5	2	4	4	6	-	2
2	.08	16	1	-	-	-	-	21	-	-	-
3	.15	7	8	3	3	2	1	5	-	1	-
4	.20	11	49	4	13	4	1	2	-	-	1
5	.11	13	16	-	16	1	1	23	1	1	-
Miscellaneous: 1 water mite											
See Key I, page 9											

These samples were taken in mid-July from varying bottoms - rock, rubble, gravel and sand, and at different depths. Mayfly nymphs seemed to predominate, while the midge larvae were present in greater abundance than the stonefly nymphs.

In general, the samples reveal a meagre bottom fauna as compared to Davis' standards.

In 1947 the average volume of a bottom sample from Sheep River was 0.5 cc. per square foot near Junction and 0.3 cc. per square foot near Coal Creek. (Miller, 1947)

The present survey shows that in the upper reaches of the Sheep River the average volume of bottom samples was 0.25 cc. per square foot and 0.15 cc. per square foot below Gorge Creek. The upper Sheep River is about half as productive of bottom fauna as Gorge Creek.

Junction Creek

This stream which is about six water miles long rises from the slopes of the Highwood Range and west slope of Pyriform Mountain, and enters the Sheep River approximately twelve miles below the source of the Sheep.

During its course it drops from 7,500 feet to 5,200 feet, about three hundred and eighty feet per mile. In spite of this very steep gradient, it is rather a gentle stream, as the descent takes place over a series of high falls. In the early spring this is a "wild" creek, with waters rising to six feet above the normal summer level. In mid-summer, the rate of flow varied from two to two and one-half miles per hour.

The upper reaches of the creek are, at places,

thirty feet wide, with numerous rapids and a fair number of pools; these are from one to two feet deep. Where the channel narrows to ten or fifteen feet with rocky sides the creek becomes a gorge. Just below these rocky gorges, pools which are crystal clear and over ten feet in depth are formed.

In the upper three miles of this stream there is a series of falls varying in height from five to fifteen feet, numbering about five per mile. In the lower two miles what were formerly falls have been covered over and built up with logs to make the stream suitable for floating logs. These structures have been in place about thirty years. They appear to make a thoroughly effective barrier to upstream fish migration, although it has been reported fish were seen in the upper parts. In these lower two miles, pools are quite numerous (fifteen per mile). They are deep and clear. Vegetation along the banks is good, but the banks are far from the summer river-bed. The early spring floods are torrential enough to remove all vegetation, so the banks may lie as far as thirty feet away from the actual water's edge. However, the banks are undercut at the turns and huge boulders offer rest havens for fish.

During the rainy season (June), Junction Creek remained quite clear as compared to Gorge and Sheep Creeks.

The temperature varied from 42° F. to 49° F. during the summer months.

The pH of Junction Creek is 8.05 which is nearly the same as the Sheep and the Gorge.

A series of ten bottom samples were taken in Junction Creek. The results are shown in Tables 10 and 11.

Table 10. The analysis of three bottom samples taken from the mouth of Junction Creek. Each sample was taken from one square foot of stream bottom.

No.	Vol. cc.	No May Ny			No Stone Ny		Miscell		
		Ba	Ri	Eph	Ac	Ne	Ca	Mi	Cra
1	.22	6	40	-	14	-	-	4	1
2	.21	15	14	2	8	-	5	1	2
3	.12	1	9	14	-	-	-	-	-
Miscellaneous: 1 Gordius, 1 planaria									
See Key I, page 9									

The average of these bottom samples is 0.18 cc. per square foot of bottom which is much lower than that recorded in this area in 1947. (Miller, 1947), (0.40 cc. per square foot). However, the relative abundance of the different forms is the same as before with the mayfly nymphs having by far the greatest numbers.

Table 11. An analysis of seven bottom samples taken two to three miles upstream from the mouth of Junction Creek. Each sample was taken from one square foot of the bottom.

No.	Vol. cc.	No May Ny			No Stone Ny		Miscell			
		Ba	Ri	Eph	Ac	Ne	Ca	Mi	Cra	Blk
1	.42	15	68	2	7	-	4	8	-	-
2	.20	17	5	-	25	-	-	4	1	-
3	.20	3	33	-	2	16	-	1	-	-
4	.45	26	56	-	3	105	1	7	-	2
5	.15	4	10	-	18	3	1	-	-	-
6	.20	7	12	-	7	3	1	-	-	-
7	.25	18	51	-	18	13	2	-	-	-
See Key I, page 9										

The first two samples were taken in early June when the temperature was 47° F. maximum. An interesting point is that there were no Nemoura present at that date, but they were present in large

numbers about mid-August when the next five samples were taken. An average sample amounted to 0.29 cc. per square foot, which indicates that the fauna is more plentiful higher upstream. The food per square foot of bottom is less than that of Gorge Creek and more than that of the Sheep River.

Blue Rock Creek

Blue Rock is a small creek, six miles long, which rises at a height of 6,000 feet and enters the Sheep River at 5,000 feet, about one mile below Junction Creek. The average gradient is one hundred and seventy feet per mile.

The upper stretches have a gentle gradient. There the stream is three to eight feet wide and flows through a wide valley covered with tall spruce. Numerous springs enter here.

About two and one-half miles above the mouth, the stream enters a gravel bed approximately two hundred yards long. It disappears under this gravel and reappears downstream. In the spring the creek rushes over this gravel.

Below this gravel bed, the stream enters a

gorge. Pools are few and there is no bank cover of vegetation.

The lower reaches are a succession of falls, the last being approximately three hundred yards above the mouth. No fish have been caught or seen above this falls. Between the falls are relatively quiet stretches (flow of one to one and one-half miles per hour) with numerous pools two to four feet deep.

Near the mouth, the stream is ten to twelve feet wide; the banks are high and there is no shade; the nearest vegetation is on the crest of the banks.

From a series of readings taken during the summer, the temperature varied from 40° F. in May to 53° F. in August.

The pH of Blue Rock Creek was 8.1, which is identical to the pH of Gorge and Sheep Rivers.

Eight bottom samples were taken. The analysis of these is shown in Table 12.

Table 12. An analysis of eight bottom samples taken from Blue Rock Creek. These samples were taken between its mouth and one mile upstream. Each sample was taken from one square foot of stream bottom.

No.	Vol. cc.	No May Ny			No Stone Ny		Miscell				
		Ba	Ri	Eph	Ac	Ne	Ca	Mi	Cra	Blk	Be
1	.10	2	39	-	4	1	-	-	-	-	-
2	.20	9	40	2	2	4	4	3	-	-	-
3	.05	1	13	-	-	-	3	1	-	-	-
4	.02	1	6	-	-	1	-	-	-	-	1
5	.12	4	36	-	5	2	-	3	-	-	-
6	.05	5	6	-	2	-	3	3	-	-	-
7	.10	4	14	-	5	-	5	2	1	-	-
8	.07	1	21	-	4	2	-	-	-	-	1
Miscellaneous: 1 oligochaete, 1 planaria											
See Key I, page 9											

The first five bottom samples were taken nearer the mouth and they averaged 0.10 cc. per square foot with mayfly nymphs predominating, especially <u>Rithrogena</u>. The last three averaged 0.07 cc. per square foot and were taken higher upstream. Again, mayfly nymphs were dominant in numbers. Blue Rock has a more meagre food supply than any other stream examined.

Dyson Creek

Dyson Creek, about five miles long, enters the Sheep River one and one-half miles below Gorge Creek. It descends from 6,000 to 4,700 feet, an average drop of two hundred and sixty feet per mile. Like Junction Creek, most of the descent is in the form of abrupt falls and the average stream velocity of one to one and one-half miles per hour is not great.

Dyson Creek above the saw mill (two and one-half miles above its mouth) divides into two branches - the North Fork coming from Junction Mountain, and the South Fork from Pyriform Mountain. Most of this stream runs through green timber, and, consequently, the banks are well covered with vegetation. There are numerous small falls and rapids with a few good pools.

Below the saw mill the creek runs through a rocky gorge, but some places have sloping banks with willow cover. The pools are numerous, but lack cover and are polluted with sawdust from the mill. The sawdust was found in pools one mile below the mill's sawdust pile which is on the stream bank. Falls

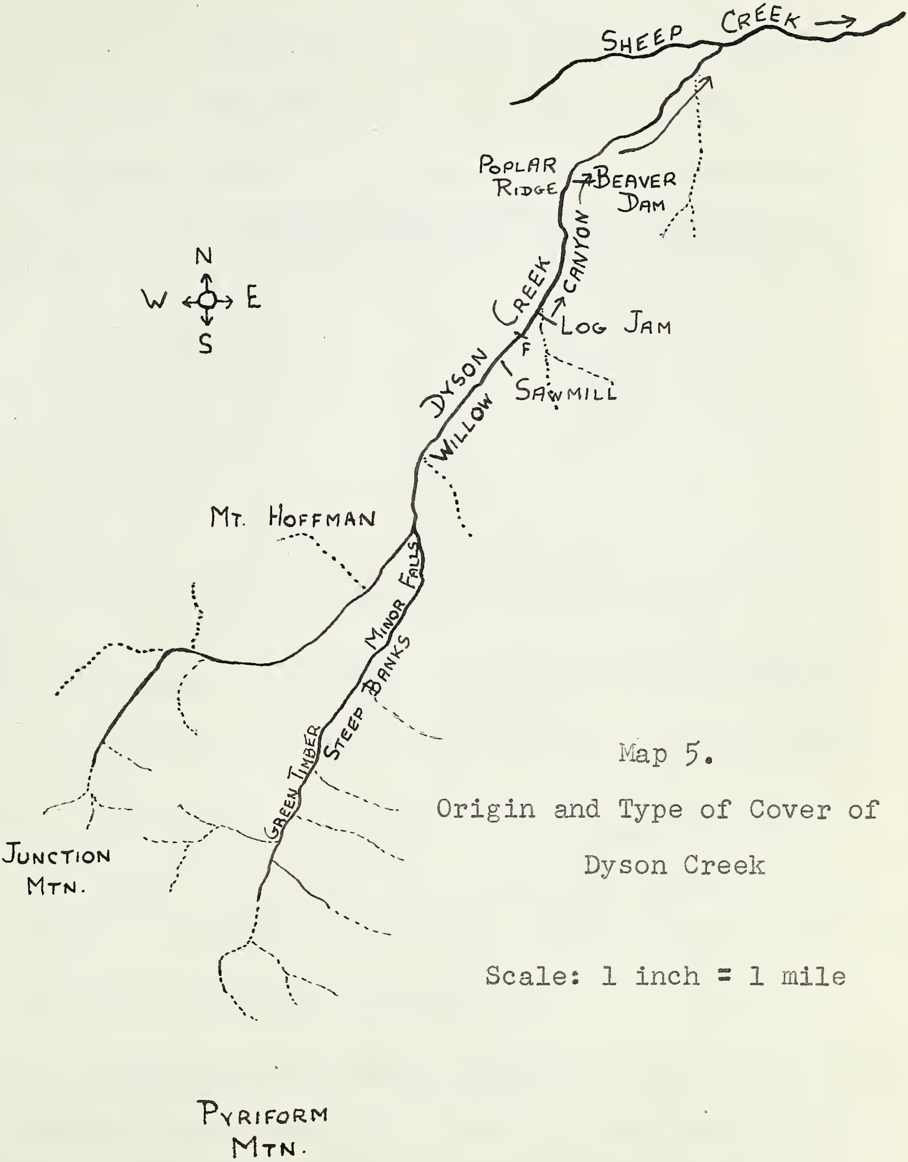
about a quarter mile below the mill are jammed with logs and slabs, and may prevent fish movement. Another fall which is just above the mill's sawdust pile is a vertical fifteen foot falls which appears to be a barrier to upstream movement. Fish were seen leaping down these falls. These may have been eastern brook trout since these were planted above the falls and were in quite good numbers in the pool below the falls (marked F on map 5).

At least two permanent springs enter the creek in its lower reaches.

The temperature fluctuates between 40° F. and 54° F.

The pH of Dyson Creek was 8.1, which is the same as all other streams of the Sheep drainage.

Ten bottom samples were taken in Dyson Creek. The analyses of these are shown in Table 13.



Map 5.

Origin and Type of Cover of

Dyson Creek

Scale: 1 inch = 1 mile

Table 13. An analysis of ten bottom samples from Dyson Creek. Each sample was taken from one square foot of stream bottom.

No.	Vol. cc.	No May Ny			No Stone Ny		Miscell				
		Ba	Ri	Eph	Ac	Ne	Ca	Mi	Cra	Blk	Be
1	.75	23	160	7	12	4	7	31	-	-	-
2	.25	13	130	-	8	2	12	16	-	-	-
3	.50	15	60	-	5	6	5	2	2	-	-
4	.27	8	44	2	12	4	-	5	-	-	-
5	.75	23	20	1	10	-	6	6	-	-	4
6	.45	23	21	-	38	3	13	14	32	3	1
7	.80	12	89	-	37	11	25	12	1	-	4
8	.65	10	66	-	14	20	9	5	-	-	9
9	.30	5	10	1	9	3	3	3	1	-	4
10	.20	1	57	3	28	9	8	8	-	-	2
Miscellaneous: 5 water mites, 10 planaria, 1 Gordius, 7 aquatic beetle larvae.											
See Key I, page 9											

The average of these bottom samples is 0.49 cc. per square foot which is the highest average of any stream in the Sheep drainage. Mayfly nymphs were present in greatest amount.

From the 1947 survey (Miller, 1947), bottom samples varied from 1.7 to 0.4 cc. per square foot. These yields are quite rich for streams in this region.

Coal Creek

Coal Creek rises at 5,500 feet and descends to the Sheep River at 4,600 feet, an average gradient of one hundred feet per mile. The North and South branches are each about three miles long and the main branch about six miles. Coal Creek enters the Sheep River approximately five miles below Dyson Creek, and directly across the Sheep from Camp Sandy McNab.

South Branch:

This rises in the rocks of Pyriform Mountain and then flows in a bed with good bank cover of willow and spruce. The bottom is of small stones. The stream itself is about fifteen feet wide and flows rather gently at one and one-half miles per hour.

The stream is well supplied with cutthroat trout; most of them were near eight inches in length.

One mile from the junction of the North and South branches are some beaver dams, with an active beaver population. No fish were seen or caught in these dams.

Temperature was 53° F.

North Branch:

The North branch flows through a muskeg, then through an area of evergreen, and, finally, willow, which covers the banks well. The stream flows in a broad valley which narrows down to a canyon at the junction of the branches.

The North branch is ten feet wide, well provided with pools and dense bank cover. The flow is about one mile per hour.

One mile from the junction are six abandoned beaver dams, now filling with mud.

There were numerous fish in the pools and riffles, the average size was well over eight inches. The fish were all beautifully coloured.

The temperature was 50° F.

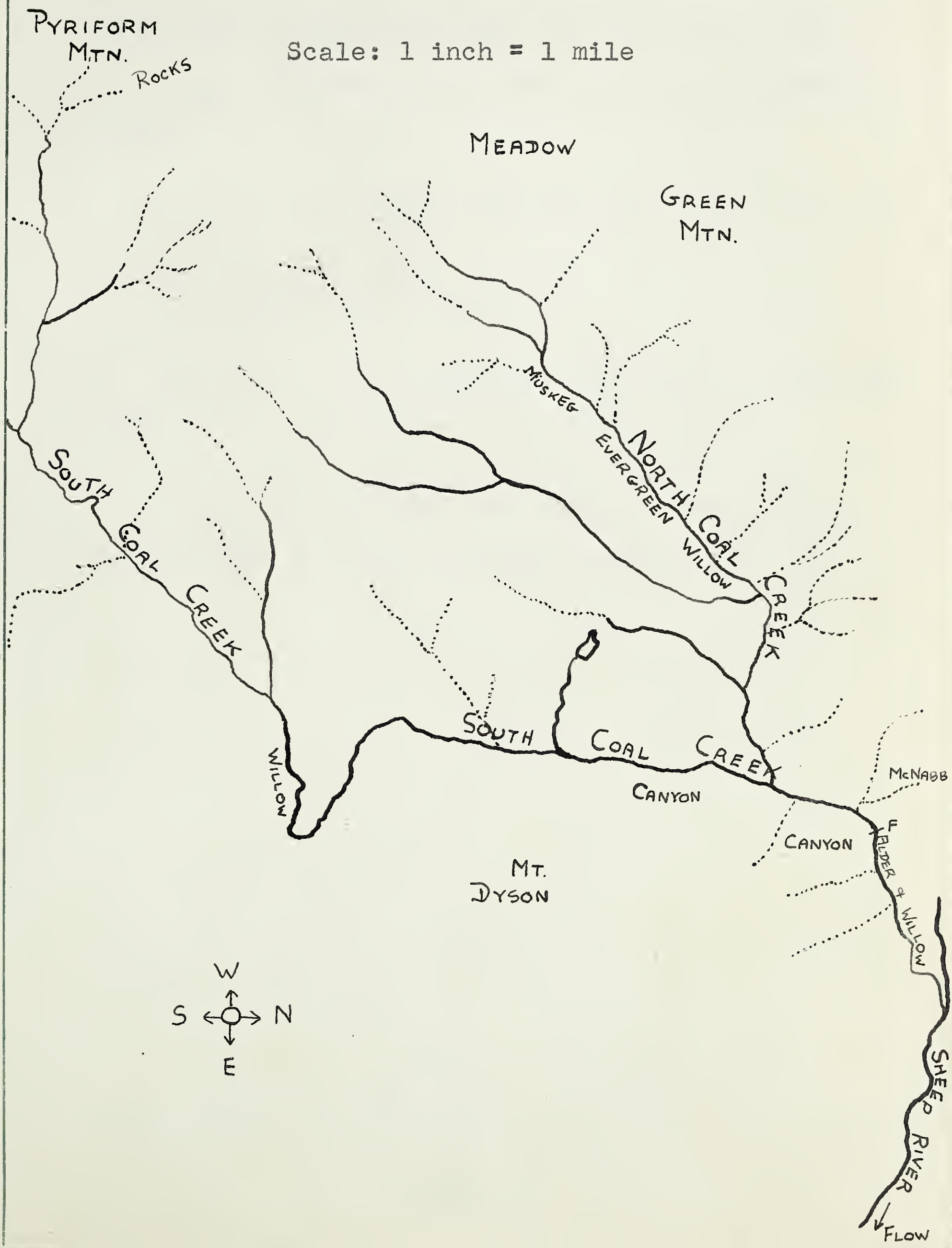
Main Branch:

This was examined near the junction of the North and South branches and near the Sheep River. It ranges in width from twenty feet at the junction to forty feet at the mouth. The first three-quarters of a mile run through a narrow gorge. The rest is open (map 6).

Map 6.

Coal Creek, Showing Vegetation and

Tributaries of Coal



Good bank cover is present, consisting of alder trees and willow. There are about fifteen pools per mile, four to five feet deep, and ten to fifteen feet long. The bottom is made up mostly of small stones.

Rate of flow is one and one-half miles per hour.

The temperature was 52° F.

The pH of Coal Creek was 8.15 which is the same as the other tributaries of the Sheep River.

Ten bottom samples were taken in Coal Creek. The analysis of these is shown in Table 14.

Table 14. An analyses of ten bottom samples from Coal Creek. Each sample was taken from one square foot of stream bottom.

No.	Vol. cc.	No May Ny Ba	Ri	Eph	No Stone Ny Ac	Ne	Miscell Ca	Mi	Cra	Blk	Be
1	1.10	22	43	1	33	-	1	2	1	-	-
2	1.05	34	51	-	70	-	-	-	2	-	-
3	.95	39	73	5	74	12	7	4	-	-	1
4	.30	33	34	-	64	-	2	-	1	-	5
5	.30	36	44	-	22	-	1	-	1	-	2
6	.30	30	32	-	11	-	1	-	2	-	3
7	.20	24	19	-	25	2	3	-	-	-	1
8	.05	1	-	-	4	1	-	1	1	-	-
9	.45	30	37	-	54	3	8	-	1	-	4
10	.25	23	69	-	19	8	4	3	-	-	2
Miscellaneous: 2 water mites, 1 planaria, 1 worm, 2 aquatic beetle larvae.											
See Key I, page 9											

These samples were taken in the latter part of August. Sample number 8 was taken from a clay and sand bar, and consequently is unproductive. The first five samples were taken from rock and gravel bottoms and the average volume here amounts to 0.72 cc. per square foot.

The over-all average is much lower than this figure (0.48 cc. per square foot). Coal Creek is a poor food stream according to Davis' standards. (Davis, 1938)

THE CUTTHROAT TROUT

Planting Records

A brief history of the fish planted in the experimental area helps to give a clearer picture of the trout situation.

All the streams with which this report is concerned were at one time or another planted with small rainbow trout, in varying numbers.

The record of the plantings is as follows (Miller, 1947):

Stream	Type Fish	Number	Date
Junction	Rainbow	12,900	Since 1941
Blue Rock	Rainbow	15,000	Since 1944
Gorge	Rainbow	15,000	Since 1944
Dyson	Rainbow	20,000	Since 1944
Coal	Rainbow	9,200	Since 1941

In addition, ten thousand cutthroat were planted in 1941 in Junction Creek.

The introduced rainbow trout do not seem to have become strongly established in these streams.

This is probably because of unsuccessful competition for food and spawning grounds with the native cutthroat trout; also, the streams have summer maximum temperature lower than that in ideal rainbow streams. The present picture is one of a predominantly cutthroat population with a small mixture of rainbows and possibly a hybrid between the two.

Recognition of Cutthroat Trout

It is difficult to distinguish the cutthroat and rainbow; the characters used for the purpose are:

Rainbow - no red slash in crease below each side of lower jaw.
- no hyoid teeth in throat.
- scales of lateral line number about one hundred and thirty-five.
- mainly black-spotted, but some red spots present.

Cutthroat - red slash in crease below each side of lower jaw.
- hyoid teeth in throat.
- scales of lateral line number around one hundred and fifty.

- entirely black-spotted - no red spots.

The favorite feature, the rainbow stripe, is not listed. This rosy band, which extends along each side of the body from cheek to tail, is present as often on cutthroat trout as it is on rainbow.

A colour study was made of one hundred specimens taken from Gorge Creek. 'Cutthroat' markings and the colouration were carefully noted for each fish. The findings are tabulated as follows:

'Cut' Mark

	Bright	Faint	Absent
No. of fish	69	16	15

All these fish had a rosy band along each side.

Taxonomic Measurements

Since the 'cut' mark is the most characteristic recognition feature of the species, it was used to divide the fish into the three groups - bright, faint and absent 'cut' mark. On each of these fish a complete series of twenty-six taxonomic measurements

was taken. (See Table 24 in appendix). Then each measurement was changed to percent of standard length. (See Table 25 in appendix). The proportionate measurements have been averaged for each of the three groups, bright 'cut' mark, faint 'cut' mark and no 'cut' mark; these averages are shown in Table 15.

Table 15. Average Proportionate Measurements of Various Body Parts of Gorge Creek Trout having Strong, Faint or no Cutthroat Mark.

	'Cut' Absent	'Cut' Faint	'Cut' Strong
No. of fish	15	16	69
H.L.	24.4	24.65	23.59
H.D.	16.6	16.64	15.69
S.	6.54	6.66	6.27
I.O.	7.13	6.88	6.56
M.	13.97	14.20	13.65
E.D.	6.07	6.46	6.48
S.-O.	17.27	17.14	16.70
O.-D.	34.72	34.86	34.5
B.W.	11.42	11.46	10.9
C.P.L.	16.46	16.32	16.16
C.P.D.	10.68	9.85	9.37
D.L.	14.68	16.08	15.38
A.D.	6.82	6.93	6.13
P_1	16.42	17.61	16.94
P_2	14.36	14.90	14.17
A.L.	14.70	14.38	13.83
P_1-P_2	32.36	31.73	31.94
P_2-A	22.37	22.58	22.24
A.B.	10.75	10.65	10.12
Scale	130.07	135.71	143.43

Key to Abbreviations Used in Table 15

H.L. - head length; H.D. - head depth; S. - snout; I.O. - interorbital; M. - maxillary; E.D. - eye diameter; S.-O. - snout to occiput; O.-D. - occiput to dorsal; B.W. - body width; B.D. - body depth; C.P.L. - caudal peduncle length; C.P.D. - caudal peduncle depth; D.L. - dorsal length; A.D. - adipose length; P_1 - pectoral; P_2 - pelvic; A.L. - anal length; P_1-P_2 - pectoral to pelvic; P_2-A - pelvic to anal; A.B. - anal base; Sc. - scales along lateral line.

The fish with 'cut' mark absent have the following differences from those fish which have a bright 'cut' mark:

No 'Cut'	Bright 'Cut'
Long head	Shorter head
Deep head	Less deep head
Long snout	Shorter snout
Long interorbital	Smaller interorbital
Long maxillary	Shorter maxillary
Small eye	Larger eye

No 'Cut'	Bright 'Cut'
Long snout to occiput	Short snout to occiput
Slightly greater occiput to dorsal	Smaller occiput to dorsal
Wide body	Less wide body
Long caudal peduncle	Shorter caudal peduncle
Deep caudal peduncle	Less deep caudal peduncle
Short dorsal fin	Longer dorsal fin
Long adipose	Shorter adipose
Short pectoral	Longer pectoral
Long anal	Shorter anal
Long pectoral to pelvic	Shorter pectoral to pelvic
Long pelvic to anal	Shorter pelvic to anal
Low scale count	Higher scale count

The fish with faint 'cut' marks are intermediate in interorbital, caudal peduncle length, caudal peduncle depth, pectoral to pelvic and scale count. They have the longest and deepest heads, longest snouts, longest maxillae, longest occiput to dorsal, widest and deepest body, and longest fins.

These fish are thus of an intermediate character in several respects, but larger than either type in

others. The intermediate characters (particularly scale count) suggest that these fish are rainbow x cutthroat hybrids; it is known that cutthroat and rainbow are so closely related that they can actually interbreed successfully. The longer heads and fins could possibly be the result of hybrid vigor.

It is tentatively concluded here that:

(1) The measurements given for these fish with strong cutthroat markings define the original native cutthroat, _Salmo clarkii (Richardson)_. It remains for some student of taxonomy to decide to what geographical race these fish will be assigned.

(2) The measurements of the fish lacking a cutthroat mark define the east slope rainbow trout, an introduced variety of _Salmo gairdnerii (Richardson)_ of unknown origin.

(3) The measurements of the fish with a faint cutthroat mark define what is probably a rainbow x cutthroat hybrid, which has arisen as a result of the introduction of the rainbow trout.

Spawning

Earliest observations began on May 25th when fish were caught and their sexual condition determined. On this date, when the water was still turbid, fish were caught with a seine. An $8\frac{1}{2}$-inch male was found to be ripe, i.e. in breeding condition. Milt flowed freely when the thunb was run down its abdomen. Further observations were made as follows:

June 1st - $8\frac{1}{2}$-and 8-inch males - latter filled with milt.

June 2nd - Two $7\frac{1}{2}$-inch females with ripe ovaries. Eggs in the fish were not yet all of uniform size. Therefore it may be concluded that spawning would be later for these fish.

June 6th - $8\frac{3}{4}$-inch female - ovaries to mature in 1949.

$9\frac{1}{4}$-inch male - milt flowed freely.

June 12th - 19.6-inch trout, female - full of eggs.

9.5-inch female trout - full of eggs.

June 18th - $7\frac{1}{4}$-inch female - extruded eggs while being fin-clipped.

June 27th - 15-inch female - just finished spawning.

June 25th - Many fish extruded eggs while being marked. One $8\frac{1}{2}$-inch female had only fifty eggs left in her, so she must have been just in the act of spawning.

July 7th - Eighteen males inspected - all had milt; twelve females - some had spawned, others with a few eggs left.

July 8th - Females - only the odd egg left in them.

July 12th - 7-inch female full of eggs - yet to spawn; male still full of milt.

At no time was the actual spawning act observed, but from these data, it would appear that the spawning season is from June 1st until mid-July.

On August 20th, numerous fry with yolk sac absorbed were noted; these must have been at least a week or ten days old. Since it takes from thirty-three to forty-four days for eggs to hatch, depending on temperature, (Needham, 1940) it can be assumed that the eggs from which these hatched were laid near the beginning of June.

The fry were abundant along the entire length of Gorge Creek. They occurred in the shallow, quiet waters along the banks. There can be no doubt that the numerous gravel beds which occur throughout the stream were all utilized for spawning. There was no concentration of fry at the headwaters to suggest a spawning migration had taken place. From these observations, it is reasonable to conclude that, in Gorge Creek, the cutthroat trout make no spawning migration.

An accurate account of the actual spawning act and location chosen in which to spawn is given by Smith (1941). He had facilities for placing sexually mature fish into closed portions of a stream. From these sections the fish could not escape, so a constant vigil could be kept over them. In addition, gravel was added to a few portions of the enclosed area, to provide more natural spawning beds. His observations in the main were:

(1) The female would not begin to dig a nest until a male was present.

(2) The female chose the location - over a gravel bed with swiftly running water

passing directly over it.

(3) The female did all the digging (two to seven hours per nest) with her tail, while the male courted her by nudging with his nose or vibrating his body near hers.

(4) The male kept other males away by chasing them.

(5) When the nest was deep enough, five to six inches, the female would arch herself into the nest with head and tail curved upwards. The male would come beside her so that their vents would be in close proximity. Both would strain at the same time, eggs and milt would be extruded simultaneously, and the eggs would drop into the nest and adhere to the rocks immediately. Only four or five eggs are lost due to water current.

(6) After the eggs are laid, the female covers the eggs by digging above the nest. The current carries gravel and sand to fill the nest. Often a mound is left above the filled nest.

(7) The female builds numerous nests and lays her eggs in bunches. It takes from two to

three days for a female to spawn completely. After she has spawned, only three or four eggs remain in the ovary.

(8) Spawning occurs both day and night.

(9) Mature males (of same species) are not interested in eating eggs at the time of mating - all try to get in on the act.

(10) 'Redds' (name given to spawning beds) may be laid in by more than one female. This overlapping causes little loss of eggs of previous layings unless the focal points of nest (deepest portions) coincide.

Cramer (1939) states that 92.5 - 98.6% of the eggs of *Salmo clarkii clarkii* are fertilized.

Gorge Creek, with its ample gravel and rock bottoms, its maximum temperature of 67° F. and good water supply, is an ideal spawning stream for cutthroat trout.

Seasonal Movements

The present regulations governing angling for trout in our east slope streams are based on the assumption that the trout winter in the main rivers,

ascend the tributaries in the spring to spawn, remain there during the summer, and drop down to the main rivers again in the fall. Most of the tributary streams are kept closed in the belief that this protects the spawning populations which will then keep the main rivers populated for anglers.

During the summer of 1947, Miller (1947) estimated the rate of growth of cutthroat trout in different tributaries of the Sheep and Highwood Rivers. Each tributary tended to have a differently growing population of trout. This suggests that the trout remain in the tributaries.

During the winter of 1947-48, Mr. W. MacDonald of Provincial Fisheries re-examined some of these streams and found trout in the tributaries.

Ranchers who live along the streams report having seen trout in the tributaries during the winter.

However, the theory that the trout do not winter in the tributaries is so firmly fixed in the popular mind that additional evidence on the question is highly desirable. In the present investigation, some evidence has been gathered.

(1) In May, during the height of the spring run-off, cutthroat trout were seined out of Gorge Creek. It seems absurd to imagine that these fish were ascending from the main river at a time when the tributaries were filled with dirt and flood waters.

(2) Out of fifty-three fish tagged in Gorge Creek in 1947 (Miller, 1947), one was recovered in 1948 (June 27, 1948). It seems probable that this fish had remained in Gorge Creek.

(3) A trap net was operated almost continuously from June 1st, 1948, to November 16th, 1948, (freeze-up) at the mouth of Gorge Creek. Part of the time the trap was arranged to take fish which might be ascending Gorge Creek from Sheep River. The rest of the time it was set to capture fish moving in the other direction. The trap formed a complete barrier from June 21st on; i.e. fish could not bypass it. The records from this trap are given in Tables 16 and 17.

Table 16. Trap net catches of fish ascending Gorge Creek from Sheep River.

Dates of Operation	Fish Caught
June 1st	1 cutthroat
June 2nd	No fish
June 10th	No fish
June 11th	1 cutthroat, 1 rainbow, 19.6 inches
June 12th to 22nd	No fish
June 23rd	3 [1]whitefish, 3 dolly varden, 5 cutthroat
June 24th	6 [1]whitefish, 1 dolly varden
June 25th, 26th	No fish
June 27th	8 [1]whitefish, 1 dolly varden
June 28th to July 8th	No fish
August 4th to 25th	No fish

[1] Rocky Mountain whitefish, Prosopium williamsoni (Girard)

Table 17. Trap net catches of fish descending Gorge Creek to Sheep River.

Dates of Operation	Fish Caught
July 9th to 18th	No fish
August 31st to October 3rd	No fish
October 4th	1 cutthroat
October 5th to 17th	No fish
October 18th	3 cutthroat
October 19th to November 16th	No fish (trap freezing up)

During June, the flood waters of Gorge Creek gradually subsided and the water became clear. This is the period when trout might be expected to return to the tributaries if they had wintered in the main rivers. However, during June and early July the trap took only seven cutthroat trout. During the same period, trout were taken by angling in Gorge Creek above the trap. These fish must have been up the stream all winter. The catching of seventeen Rocky Mountain whitefish moving upstream confirms the well-known migrating habits of the species. The movements of dolly varden (*Salvelinus malma (Walbaum)*) are, as yet, unstudied.

During late summer and fall, up to winter and freeze-up, the trap took only four cutthroat trout going downstream. There is obviously no migration out of Gorge Creek in the fall. Two further observations confirm the trap net records. One is that during this period, hundreds of trout were caught by angling in Gorge Creek; i.e. the trout were definitely still in the stream. The other is that of the fifty-eight trout marked in South Gorge Creek, not a single specimen was recaptured in Main Gorge (i.e. downstream of point of marking) out of four hundred and three fish caught. In fact, it was noticed that recaptures of marked fish were made in the vicinity where the fish had been marked.

Winter observations made by Mr. W. MacDonald have revealed that Gorge Creek freezes to the bottom in its shallower stretches. Thus trout cannot migrate out of the tributaries in winter. The conclusion is obvious: the native cutthroat trout must remain in the tributaries winter and summer.

Population Density

A few hours of angling is usually enough to

inform an experienced fisherman of the abundance of trout in a stream. But angling or observation of the stream can only give relative ideas of population densities. It is desirable to learn, if possible, the actual number of fish present. In Gorge Creek, an effort was made to estimate the population of cutthroat trout by a marking experiment.

The marking technique of Petersen (1896) was employed. Trout were secured by angling, from each a fin was removed with tin snips and the fish returned to the water. The number of marked fish recaptured in subsequent angling enables a rough population estimate. Thus, if N fish are marked and R marked fish are recaptured in a total catch of H fish, then P (the population) is given by the formula:

$$P = \frac{NH}{R} \quad \text{(Ricker, 1948)}$$

It is assumed that the marked fish suffer no greater mortality than the unmarked, that they remain in the stream and that they are as vulnerable to capture as unmarked fish. It is believed that in the area studied, these assumptions are justifiable.

Marking was done in main Gorge Creek, largely in the section below the junction of North and South Forks, and in South Gorge. The right pectoral fin was removed in the former area, the right pelvic in the latter. Thus, if the fish moved around much from headwaters to lower waters or vice versa, such movements could be detected.

The totals of the fish marked on various dates and the cumulative totals of marked fish at large for the upper section of the Gorge Creek are shown in Table 18.

Table 18. Records of trout marked and recaptured in main Gorge Creek from the falls to the switchback (see map 3).

Date	Number Marked	Total Catch	Recaptures	Total Marked at Large
May 24th	9	12	-	9
May 25th	6	6	-	15
June 2nd	1	7	-	16
June 18th	11	31	-	27
June 25th	20	29	-	47
June 29th	-	16	2	47
July 7th	16	63	2 (killed)	61
July 12th	-	25	2 (killed)	59
July 21st	-	22	1 (killed)	58
August 3rd	-	16	4 (killed)	54
August 25th	-	176	3	54
Totals	63	403	14	

From the formula given previously, it would be possible to make population estimates each time fish were recaptured. Because of the small number of recaptures, however, these would be too inaccurate to be of value. Accordingly, a Schnable-type estimate has been used (Schnable, 1938), employing Ricker's (1948) modified formula. This is:

$$P = \frac{\Sigma(AB)}{\Sigma C}, \text{ where,}$$

P is the total population,

A is each day's catch,

B is the total marked fish at large,

C is the marked fish caught each day.

Picking from Table 18 the data which show returns of marked fish and using them in this formula, the population estimate for Gorge Creek from the falls to switchback is:

	A	B	AB	C
July 7th	63	47	2,961	2
July 12th	25	61	1,525	2
July 21st	22	59	1,298	1
August 3rd	16	58	928	4
August 25th	176	54	9,504	3
			ΣAB 16,216	ΣC 12

$$P = \frac{16,216}{12} = \underline{1,351} \text{ fish}$$

This portion of Gorge Creek is 1.12 miles long. The population estimate becomes, therefore, 1,206 fish per mile.

In that part of Gorge Creek below the switch-back and downstream to its mouth, eleven fish were marked in 1948. A total of one hundred and fourteen fish were caught. The details are shown in Table 19.

Table 19. Fish marked in main Gorge Creek from switch-back downstream to mouth.

Date	Number Marked	Total Catch	Recaptures	Total Marked at Large
May 31st to July 8th	5	27	0	5
July 25th to July 27th	6	30	0	11
August 1st	0	34	1 (killed)	10
August 5th	0	14	1 (killed)	9
August 17th	0	9	0	9
	11	114	2	

Treating these data in the same way as those of Table 18, a population estimate of 257 fish is reached. Due to the small numbers of marked fish and recaptures, this estimate is not reliable.

In South Gorge Creek a total of fifty-eight fish were marked, but in subsequent angling, although one hundred and two fish were caught, no recaptures were made. No population estimate is possible. The population must have been fairly large, however, as, on one occasion, a single pool, fifty by fifteen feet, yielded twenty-seven fish with an average length of 8.16 inches.

Miller, 1947, using the same technique and formula (on North Fork of the Sheep River) found the population to be approximately four hundred fish per mile.

It appears from the 1947 and 1948 estimates that the trout population of Gorge Creek lies between eight hundred and sixteen hundred per mile, with one thousand two hundred fish per mile seeming to be a good average.

Schuck (1941) states that three hundred and ninety-six legal-sized brook trout per mile (seven inches tail length) would provide suitable angling for twenty-one days with angling pressure of eleven and four-tenths hours per day and would give at least one fish per angler per hour of fishing.

Shetter & Leonard (1940) state that the complete population of five hundred eighty and one-half feet of Hunt Creek, Michigan, was six hundred and five brook trout or five thousand, four hundred and forty-five fish per mile; in addition there were one hundred and eighty-eight muddlers per five hundred eighty and one-half feet or one thousand, six hundred and ninety-two muddlers per mile.

In Table 20 the percentages of fish over seven inches and over eight inches in tail length caught in four of the cutthroat streams are listed.

Table 20. Size distribution of cutthroat trout.

Stream	Year	Number Caught	% 7 inches and over	% 8 inches and over
S. Sheep	1948	22	100	100
N. Coal	1948	31	77.4	41.9
S. Coal	1948	18	88.8	55.5
Dyson	1948	9	77.7	66.7
Gorge	1947	60	85.0	40.0
Gorge	1948	142	78.2	35.2

From this table we can see that from random angling in the above streams, at least 77% of all the fish are seven inches long or over, while as few as 35% reach eight inches.

Gorge Creek is the stream with the lowest percentage of eight-inch fish. This means that two out of every three fish must be thrown back by the Alberta angler. Since Gorge Creek has been closed to sportsmen for a good many years, the high percentage of small fish is not the result of fishing, but must be a natural phenomenon due to high mortality rate. In numbers of seven-inch trout per mile, Gorge Creek compares very favorably with Schuck's standard of three hundred and ninety-six per mile required to produce suitable angling.

Growth in Different Streams

One hundred and thirty-four cutthroat trout from Gorge Creek were measured, weighed and scale samples were taken from each. Each scale sample was cleaned and mounted on a glass slide in glycerine jelly. From a microscopic study of markings, an estimate of the age of each fish was made. This is a somewhat uncertain task as trout scales are very difficult to interpret. Next, the average length and weight of each age group was calculated.

Six fish from Dyson Creek and thirty fish from

the North Coal were treated in the same way. In addition, twenty-two fish from Sheep Creek above the Ranger Station and eighteen fish from South Coal Creek were also measured and scale samples mounted, but weights were not recorded.

The results of the scale studies of these fish are shown in Table 21.

Table 21. Average length (in inches) and weight (in ounces) of cutthroat trout of each age taken in Gorge, Dyson, Coal and Sheep Creeks. (1947 data from Miller, 1947)

Age	Number of fish	Length in inches	Weight in ounces
Gorge, 1947			
1	-	-	-
2	27	7.11	2.67
3	31	8.12	3.41
Gorge, 1948			
1	8	7.41	2.28
2	76	7.61	2.58
3	42	7.71	2.50
4	7	7.90	2.53
5 ?	1	19.60	39.00
Dyson, 1948			
1	2	6.75	1.83
2	6	8.69	4.97
North Coal, 1948			
1	15	6.38	1.97
2	15	8.95	3.99

Age	Number of fish	Length in inches	Weight in ounces
South Coal, 1948			
1	4	7.12	
2	14	8.16	
Sheep, 1948			
1	2	9.00	
2	12	10.60	
3	8	12.58	

As rather small samples were studied in some streams, the findings cannot be regarded as fully trustworthy.

A study of Table 21 shows a remarkable variation in the sizes of fish of the same age from different streams. For example, average length of a two-year-old from Sheep River is ten and six-tenths inches, whereas an average two-year-old in Gorge is only seven and sixty-one one-hundreths inches. The explanation of the wide variation in growth in different streams must lie in the character of the streams.

In Table 22 the four streams are arranged in the order of the growth rate of their cutthroat trout. Various environmental factors of each stream are listed (data from Tables 1-11, 13 and 14).

Table 22. A comparison of environmental factors in four streams.

Stream	Food cc. per sq. ft.	pH	Temp. ^{0} F.	Pools	Cover	Velocity m.p.h.	Size
Sheep	.15-.25	8.1	40-50	Average	Fair	3.4	Large
Coal	.48	8.15	40-53	Fair	Good	1.5	Small
Dyson	.49	8.1	40-54	Fair	Good	1.5	Small
Gorge	.35	8.1	40-67	Fair	Fair	1.5	Small

The fastest growing cutthroat were taken from Sheep River. From Table 22 it may be seen that this river differs from the other streams in being larger and swifter. It is probably the size which is significant as it is well-known that the size of the container conditions the growth of aquarium fishes. Also the population density is undoubtedly much less than in the tributaries so that, although the total food supply is less, there would be more food per fish.

Of the three small streams, Coal and Dyson show no significant differences in the rate of growth of their cutthroat trout. Table 22 shows that this might be expected; the streams are very nearly identical in food supply, pH, temperature range, size,

pools, velocity and cover. The Gorge Creek trout grow significantly more slowly. Table 22 shows that Gorge Creek has a poorer food supply than Coal or Dyson and also poorer pools and cover. It is possible, therefore, to associate good growth with food, pools and cover.

Miller (1947) examined a number of streams of the Sheep and Highwood and found that where significant differences occurred, the growth rate was faster in the warmer streams. The streams of Table 22 do not show very large temperature differences. However, Junction and Blue Rock Creeks, where cutthroat do not occur, are significantly colder. It is possible that the low temperatures of these streams determine the absence of trout in them.

Age at Maturity and Mortality

Table 23 shows the distribution of mature and immature fish from Gorge Creek.

Table 23. Weights (ounces) of fifty-four mature and immature trout from Gorge Creek.

	Mature	Immature
Number	22	32
Weight	2.8	-2.5
Age (years)	2-3	up to 2

From Table 23 it is apparent that the cutthroat mature during the second or third year. Very few fish much beyond the age of maturity were found. From Table 21 it is evident that only 6% of the fish were four years or older. Miller (1947) in a survey of the Sheep, Highwood and Jumping Pound streams also found a high percentage of young trout. Shetter & Leonard (1940) found that the percentage of brook trout of each age in a stream decreases from year to year as follows:

Group 0 - less than one year - 46.7%
Group I - less than two years - 30.8%
Group II - less than three years - 19.8%
Group III - less than four years - 2.7%

These data suggest a rather high rate of mortality. The age composition for Gorge Creek in 1948

also suggest a high mortality. There were seventy-six two-year-olds, forty-two three-year-olds and seven four-year-olds caught. This suggests a mortality of nearly 50% from age two to age three and about 85% from age three to age four (assuming each age group was of the same abundance when hatched). Further, out of fifty-three fish marked by Miller in Gorge Creek in 1947, only one was recovered in 1948. This also suggests a rather high mortality.

DISCUSSION AND CONCLUSIONS

One of the principal contributions of this study has been to establish a large series of measurements of fresh cutthroat trout, taken in a situation where there has been a minimum of interference by the introduction of exotic species. These measurements establish the characteristics of the native trout and will facilitate subsequent separation of native trout in areas where considerable interbreeding with introduced forms may have taken place. The measurements also suggest that some mingling of

native and foreign stocks has already occurred; they offer a clue to the kind of variations that may be anticipated where considerable hybridization has occurred, for example, in the Bow River. Complete records of the absolute measurements of the fish are included in the appendix so that, if a taxonomic study of the native trout is undertaken, it will be possible to describe its original characteristics with considerable accuracy.

This study also throws some light on the problem of cutthroat movements. A combination of marking experiments, trap netting and winter observations strongly suggest that these trout remain in the tributary streams and perform no extensive seasonal migrations. This conclusion has an important bearing on the management of east slope streams. The present policy of keeping tributaries closed as "feeder" streams is based on a misconception. The fish thus protected are not contributing to the main stream populations but, instead, die of natural causes and contribute nothing to the angler. These streams should be open to fishing. This conclusion is strengthened by the data on winter mortality. The age composition of the cutthroat indicate that few live

beyond an age of three years. It would be more economical to allow some of these fish to be caught by anglers.

The findings on population density will be of considerable value for assessing the effects of fishing if these tributaries are opened to anglers. The estimates of the number of cutthroat in Gorge Creek provide a standard for an unfished stream. Estimates made from fished streams may be compared with the Gorge Creek figures to give an idea of the effect of fishing on the population.

Another contribution of this study has been to estimate the growth rates of fish from different streams. These estimates show that fish in different streams grow at different rates. This strengthens the conclusion that all fish do not drop into the main tributary to winter. Another aspect of growth rate study is that in some streams fish are mature and spawning at the age of two and three, but are still not in the legal catch size limit of eight inches. In view of the heavy natural mortality, it may be advisable to lower the size limit to seven inches for some time, at least in the South Sheep River drainage.

The study of environmental factors may be co-related to some extent with the study of the trout. Thus, of the six streams studied, two contain no cutthroat trout. These are Blue Rock and Junction Creeks. In food supply, these do not appear to differ enough from trout-containing streams to prevent trout growth. But in lack of cover, cold water and high falls near the mouth, they differ from the other streams. Probably the high falls alone are enough to explain the absence of trout. Some information on falls constituting a barrier to trout movement is provided by the falls on North Gorge Creek at its junction with South Gorge. These falls are in two steps, each a rise of 13.8 feet in one hundred feet; the lower is forty-seven feet long and the upper one hundred and eighty. Fish were observed climbing the forty-seven foot slope, but not the one hundred and eighty foot slope.

In the four streams which contained cutthroat trout, the best growth was observed in the main Sheep River. This is probably due to a sparse population living in a large area, so that food supply per fish is quite good. In the three small

trout-containing tributaries, better growth is definitely associated with more food, more pools and better cover.

In general, the growth rates of the cutthroat trout in all streams are poor. The explanation undoubtedly lies in the low food supply, which does not exceed 0.5 cc. per square foot. Davis (1938) classifies streams with less than 1 cc. per square foot of bottom food as poor.

SUMMARY

This paper presents data on cutthroat trout, environmental factors, biology of the trout and its relationship to its environment which were secured during a summer survey of parts of the Sheep River drainage in 1948.

Cutthroat, the native trout, provide almost all the angling in this drainage. An account of their taxonomic characters and colour characters is presented. These taxonomic measurements distinguish the cutthroat from the exotic species of rain-

bow that has been introduced at intervals since 1941. Hybrids may have resulted from this operation.

The growth rate of the cutthroat in four streams is given and an attempt is made to correlate the growth with stream conditions.

Observations on age (from scale readings) and size show that the present legal limit may be slightly high for fish of the South Sheep drainage, in that many fish die before reaching the legal length.

Studies of population densities in Gorge Creek are outlined.

A discussion of seasonal movements of cutthroat trout is presented.

An account of rates of flow, cover, temperatures, pH and bottom faunas of the streams examined is presented. Two of these streams were without cutthroat trout and their absence is tentatively associated with low temperatures and high falls.

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KEY TO APPENDIX, TABLES 24 and 25.

Wt. - weight; T.L. - tail; S.L. - standard length; H.L. - head length; H.D. - head depth; S. - snout; I.O. - inter orbital; M. - maxillary; E.D. - eye diameter; S-O - snout to occiput; B.W. - body width; B.D. - body depth; C.P.L. - caudal peduncle length; C.P.D. - caudal peduncle depth; D.L. - dorsal length; A.D. - adipose length; P_1 - pectoral length; P_2 - pelvic length; A.L. - anal length; A.R. - anal ray; G.R. - gill rakers; L.L.S. - lateral line scale; P_1-P_2 - pectoral to pelvic; P_2- A. - pelvic to anal; A.B. - anal base.

APPENDIX

TABLE 24 - MEASUREMENTS OF 101 TROUT FROM GORGE CREEK (T.L. in inches, other measurements in mm.)

No. 1	Wt.	T.L.	S.L.	H.L.	H.D.	S.	I.O.	M.	E.D.	S. to O	O. to D	B.W.	B.D.	C. P.L.	C. P.D.	D.L.	A.D.	P_1	P_2	A.L.	A.R.	G.R.	L. L.S.	P_1 P_2	P_2 A.	A.B.
1.	39 oz.	19.6	400	103	68	34	38	60	18	75	150	55	91	70	48	66	25	66	59	59	11	7+11 =18	146	148	118	46
2.	100 gms	8.4	185	43	29	12	12	25	12	31	63	22	40	25	20	34	15	33	28	24	11	7+9 =16	139	64	40	23
3.	110	8.1	180	47	33	16	12	27	16	36	61	22	47	26	22	33	16	34	27	25	11	7+10 =17		59	36	23
4.	100	8.5	190	54	38	16	17	33	14	38	60	20	43	32	20	30	14	35	30	25	10	7+10 =17		51	38	19
5.	100	8.5	190	46	32	12	13	24	12	32	68	26	41	32	24	32	15	30	25	27	10	7+9 =16		52	40	22
6.	55	7.4	165	40	26	11	11	22	11	29	61	22	39	27	17	27	10	27	22	24	10	6+8 =14		48	40	17
7.	50	6.9	155	38	23	10	9	21	10	25	50	19	35	24	17	23	10	23	21	22	10	7+8 =15		55	38	16
8.	65	7.2	157	39	26	9	11	22	11	28	55	21	40	21	18	27	9	24	20	23	10	7+8 =15		55	32	11
9.	70	7.9	178	42	28	10	12	23	12	31	60	19	38	23	20	28	12	30	22	26	11	7+9 =16		52	34	20
10.	50	6.9	155	38	23	9	9	20	11	26	50	17	31	25	17	25	9	27	18	20	10	7+9 =16		53	30	16
11.	50	6.9	155	38	24	9	9	20	11	26	53	19	35	25	16	25	8	27	21	22	10	6+8 =14		50	31	15
12.	550	14.8	338	76	54	21	26	41	16	49	105	44	80	55	34	48	25	49	44	41	12	8+11 =19	136	119	78	37
13.	150	9.5	216	53	34	13	16	30	12	35	24	30	56	38	26	29	16	32	29	31	11	8+10 =18	159	72	46	23

Appendix. Table 24, (2)

14.	120	8.6	196	51	34	13	15	31	12	35	70	28	51	32	22	30	15	32	27	29	11	7+9 =16		65	44	23
15.	125	9.3	208	53	35	12	15	29	11	36	68	28	48	30	23	32	15	35	28	33	11	8+8 =16	145	69	45	23
16.	125	9.0	206	54	35	17	18	33	12	38	75	26	45	32	22	29	15	38	28	34	11	7+9 =16	124	64	49	21
17.	100	9.1	200	49	32	15	15	29	12	38	70	24	47	32	21	29	13	39	28	32	11	6+9 =15	160	66	47	21
18.	80	7.9	178	46	30	14	14	26	10	30	57	22	44	30	20	27	15	32	28	28	11	7+8 =15	134	56	30	17
19.	70	8.0	175	41	27	10	14	25	10	29	62	20	42	28	19	24	10	30	23	28	10	7+9 =16	147	59	39	17
20.	100	8.5	190	44	29	10	14	23	10	59	61	24	47	28	20	26	12	31	26	28	11	7+8 =15	136	64	47	18
21.	50	7.5	165	40	27	10	12	23	10	28	55	19	38	25	18	25	10	29	23	25	11	7+9 =16	130	55	40	16
22.	70	8.1	180	42	27	9	12	22	11	28	63	19	41	25	18	25	10	30	25	23	10	6+8 =14	152	57	42	17
23.	70	7.8	198	41	26	10	12	23	10	28	59	19	41	24	18	26	8	28	24	20	10	6+8 =14	148	59	43	15
24.	50	7.3	185	39	25	10	11	21	10	27	58	18	39	24	17	25	8	28	22	22	10	7+6 =13	163	57	37	15
25.	70	7.8	175	43	29	12	12	23	10	27	59	21	42	26	19	28	10	27	21	25	10	8+10 =18	154	56	41	17
26.	60	7.3	163	38	25	11	10	21	11	26	57	20	38	24	18	27	10	27	22	25	10	8+5 =13	150	52	39	17
27.	75	7.9	173	43	29	11	11	24	10	26	62	21	44	25	17	25	10	30	25	25	10	7+8 =15	136	54	39	17
28.	45	6.3	147	38	26	10	9	21	9	25	48	19	38	23	16	25	10	26	23	22	10	8+6 =14	135	42	32	15
29.	70	7.5	160	40	27	10	11	24	11	26	60	19	41	25	17	28	12	29	27	23	10	7+6 =13	136	55	36	16

Appendix. Table 24 (3)

30.	55	6.9	152	39	27	10	11	23	10	28	50	18	36	25	17	27	11	28	25	24	11	8+7 =15	143	49	37	16
31.	75	8	175	41	28	10	12	25	11	28	59	21	42	27	18	27	11	30	25	26	11	7+9 =16	152	58	40	18
32.	60	7.5	170	40	27	10	11	23	11	28	59	19	42	26	17	24	10	28	24	23	10	6+9 =15	127	56	38	16
33.	50	6.8	150	35	24	9	9	21	11	26	53	18	35	24	16	20	9	27	23	23	10	6+8 =14	137	49	37	15
34.	60	6.8	153	35	25	9	9	20	11	26	54	18	38	24	16	21	9	27	22	21	11	7+8 =15	150	54	39	16
35.	75	7.9	175	40	26	11	12	24	11	28	57	20	40	26	18	26	11	30	24	24	11	7+8 =15	148	57	39	17
36.	50	6.5	145	35	23	9	10	20	9	24	50	18	38	24	16	21	9	24	21	20	10	7+8 =15	150	43	37	14
37.	35	6.0	140	33	21	7	8	18	8	23	45	16	32	20	15	20	8	23	19	18	10	8+6 =14	137	43	32	13
38.	90	8.1	183	43	28	13	13	25	12	30	62	20	42	29	18	32	15	32	27	30	11	6+7 =13	159	65	40	21
39.	80	7.9	175	42	30	14	13	27	12	30	62	20	42	30	18	27	12	30	25	25	11	7+8 =15	148	60	40	18
40.	25	5.7	132	31	19	7	8	18	9	23	42	12	29	22	12	22	8	23	18	18	11	7+7 =14	143	40	30	14
41.	100	8.4	185	48	32	14	14	30	12	34	65	20	46	29	18	30	12	32	28	27	10	8+9 =17	150	62	41	18
42.	60	7.4	168	42	27	13	11	24	11	29	60	18	38	27	16	25	10	30	25	25	11	8+6 =14	153	54	35	18
43.	65	7.7	170	45	29	11	11	26	12	32	60	17	42	27	17	25	13	30	27	26	11	8+9 =17	143	53	35	19
44.	60	7.9	173	42	29	11	12	26	12	30	59	17	40	26	15	28	13	30	27	24	10	8+10 =18	145	56	38	17
45.	55	7.2	160	42	29	11	11	23	10	29	59	17	40	25	15	27	13	30	27	25	10	8+10 =18	137	50	35	18

Appendix. Table 24 (4)

46.	50	7.1	158	37	25	10	10	21	12	25	59	17	35	26	14	25	10	28	25	22	10	7+8 =15	153	52	35	17
47.	90	8.2	185	45	30	13	12	28	12	32	69	20	44	30	16	29	10	33	24	26	10	8+10 =18	141	58	41	20
48.	85	8.3	188	43	30	11	12	24	12	30	69	20	44	31	16	30	10	33	27	28	10	8+8 =16	145	58	45	19
49.	60	7.3	163	42	28	11	12	23	12	30	66	17	41	27	16	25	11	30	25	24	10	7+8 =15	141	52	36	17
50.	80	8.2	183	46	30	12	13	27	13	31	67	21	43	31	18	27	11	34	28	25	10	7+8 =15	128	60	38	20
51.	60	7.7	173	42	26	11	12	25	13	28	66	17	43	30	16	25	10	30	26	26	10	6+9 =15	137	54	38	19
52.	50	7.4	165	39	25	11	11	21	12	27	59	17	38	26	14	23	9	30	26	25	10	7+8 =15	150	54	38	17
53.	65	7.7	170	41	26	11	11	23	12	27	62	18	39	26	16	25	9	30	26	24	10	8+9 =17	138	54	40	15
54.	110	8.9	201	52	34	15	14	31	13	32	75	22	47	33	20	30	14	36	30	32	10	7+8 =15	135	66	49	30
55.	100	8.4	191	49	32	14	14	27	12	31	67	22	46	30	18	25	13	33	30	30	12	8+7 =15	128	59	39	22
56.	60	7.4	168	43	26	12	11	24	11	26	60	18	39	27	15	26	13	30	26	23	11	7+8 =15	142	52	35	18
57.	55	7.2	158	38	25	10	10	22	10	25	58	17	38	26	15	25	11	30	25	23	10	7+9 =16	151	50	37	17
58.	30	6.6	147	36	22	9	10	20	9	25	52	14	35	28	13	24	9	25	20	18	9	7+9 =16		49	35	15
59.	45	7.3	163	41	26	11	12	24	12	25	60	16	39	27	13	27	10	29	25	24	10	6+9 =15	125	52	38	18
60.	60	8.0	180	42	29	12	12	23	12	26	60	19	39	30	15	32	11	29	25	23	11	8+6 =14	125	57	38	20
61.	30	6.7	150	36	21	10	9	20	10	24	53	16	34	26	12	21	7	24	20	20	10	7+7 =14	140	48	33	14

Appendix. Table 24 (5)

62.	30	6.5	147	33	21	10	9	20	10	24	53	15	34	26	11	24	8	22	20	19	11	7+8 =15	125	46	31	15
63.	75	8.0	180	42	29	11	11	27	11	30	67	19	42	29	15	26	11	32	26	25	10	8+8 =16	122	57	36	17
64.	30	6.5	145	37	23	10	10	21	10	27	52	16	34	27	13	21	8	25	21	22	11	8+7 =15	118	41	37	15
65.	60	7.9	178	41	30	11	11	25	11	30	61	18	40	31	14	27	7	30	25	23	10	----	140	54	37	17
66.	55	7.8	175	40	28	10	11	23	12	29	58	18	40	32	14	28	10	30	23	24	11	7+9 =16	156	59	41	17
67.	100	8.5	193	43	31	11	12	27	12	32	71	20	48	35	16	30	12	34	24	29	11	8+9 =17	126	59	45	20
68.	110	9.0	203	45	32	12	12	27	12	32	72	21	49	35	18	32	9	32	29	30	10	8+9 =17	131	62	50	20
69.	50	6.3	140	33	25	10	9	20	9	25	51	18	37	24	13	24	11	25	23	20	10	10+8 =18	142	47	32	18
70.	100	8.3	191	46	34	11	12	28	11	32	70	20	45	31	17	34	12	33	28	23	11	8+9 =17	137	59	45	20
71.	80	8.1	183	42	30	11	12	25	12	30	65	20	38	30	14	30	10	32	27	24	10	7+8 =15	145	59	41	17
72.	50	7.7	125	36	27	11	10	22	11	28	60	17	37	28	12	28	11	29	25	23	10	8+6 =14	135	55	38	16
73.	95	8.2	186	46	31	12	12	28	11	32	62	19	45	32	16	30	12	32	29	25	11	8+11 =19	146	57	38	19
74.	50	7.0	157	34	25	10	10	23	10	28	52	16	35	29	13	25	9	28	23	22	10	6+7 =13	160	52	37	17
75.	55	7.7	175	40	29	11	12	24	10	29	60	17	40	31	14	26	11	23	25	24	11	6+8 =14	138	52	40	18
76.	55	7.2	163	40	28	12	12	23	10	29	55	19	37	29	14	25	11	29	26	25	10	6+9 =15	140	50	33	17
77.	45	6.9	153	34	25	10	11	22	10	28	55	16	37	28	14	25	10	27	24	20	9	7+8 =15	147	47	36	16

Appendix. Table 24 (6)

78.	55	7.5	170	38	25	10	11	22	10	29	58	16	39	31	14	26	11	29	23	24	9	6+10 =16	134	54	36	17
79.	65	7.8	175	38	25	10	11	22	11	29	58	17	41	30	14	25	12	28	25	23	11	7+8 =15	156	56	40	17
80.	45	6.4	147	34	21	8	10	20	9	28	50	14	34	24	13	23	10	25	20	20	10	6+7 =13	141	45	35	14
81.	70	7.5	170	40	27	11	11	24	11	29	62	17	38	28	15	26	10	31	25	22	10	7+10 =17	140	51	40	19
82.	50	7.0	160	38	25	12	11	20	10	29	54	16	38	29	14	25	11	27	22	17	10	----	129	44	35	15
83.	55	7.2	163	36	25	10	10	20	10	28	56	17	36	27	14	26	10	32	24	20	11	6+9 =15	143	49	36	16
84.	55	6.9	158	40	26	10	11	20	10	28	54	17	36	28	14	27	12	31	23	22	10	8+10 =18	125	50	37	17
85.	100	8.6	193	47	30	14	13	30	12	34	62	20	45	32	16	32	12	32	27	23	10	8+10 =18	130	62	40	20
86.	75	7.9	180	45	29	13	12	36	12	32	60	19	42	30	15	31	13	32	26	25	10	6+9 =15	137	52	40	18
87.	55	7.6	170	40	25	10	12	22	11	29	58	18	42	29	15	27	10	28	26	22	10	7+9 =16	129	52	40	17
88.	50	6.9	155	36	23	10	11	21	11	28	51	16	35	27	13	26	10	28	22	22	10	6+9 =15	125	50	33	15
89.	75	8.3	188	43	28	11	11	25	13	29	63	19	44	32	15	28	10	34	26	26	9	7+8 =15	150	61	46	17
90.	50	7.1	160	39	23	9	11	21	12	28	54	17	38	28	13	22	8	28	22	22	10	----	151	50	35	14
91.	25	6.3	148	32	22	9	9	20	10	25	47	15	30	23	12	21	7	26	19	18	10	6+7 =13	135	45	34	13
92.	70	7.8	173	43	29	12	11	22	12	28	60	17	35	30	17	23	11	28	25	23	10	7+10 =17	150	61	38	18
93.	45	6.3	142	32	23	9	10	19	10	23	59	14	32	25	15	20	10	22	21	20	10	----	140	48	32	16

Appendix. Table 24 (7)

94.	45	6.3	145	32	22	9	10	20	10	24	54	14	34	27	16	22	8	25	22	20	10	6+8 =14	140	47	33	16
95.	75	7.4	165	38	27	10	10	23	10	27	55	16	35	30	16	22	10	25	23	23	10	6+8 =14	155	54	36	18
96.	50	6.3	145	35	22	9	10	20	10	24	53	15	31	22	15	21	9	23	21	21	10	6+8 =14	152	45	36	16
97.	55	6.4	198	35	23	9	10	18	10	24	47	15	33	24	16	21	10	21	21	20	10	7+9. =16	125	52	33	17
98.	75	7.3	163	41	30	11	11	21	10	29	58	18	44	25	19	24	11	29	25	26	11	7+7 =14	120	60	35	18
99.	75	7.4	168	41	30	11	11	25	10	29	58	18	38	28	19	25	13	30	26	28	11	9+9 =18	122	57	37	19
100.	70	7.2	165	37	26	8	10	21	10	28	52	17	38	27	18	25	13	25	21	23	11	7+9 =16	129	57	36	18
101.	75	7.5	168	42	27	9	11	24	10	30	56	18	38	30	19	25	12	30	24	22	11	7+9 =16	110	62	37	18

Appendix.

TABLE 25. Proportionate Measurement of 101 Trout from Gorge Creek.
Actual Standard Length expressed in mm.; other measurements as percentages of Standard Lengths.

	S.L.	H.L.	H.D.	S.	I.O.	M.	E.D.	S. to O.	O.D.	B.W.	B.D.	C. P.L.	C. P.D.	D.L.	A.D.	P_1	P_2	A.L.	P_1P_2	P_2A	A.B.	Sc.
1.	440	23.3	15.5	7.7	8.6	13.6	4.1	17.1	34.1	12.5	20.7	15.9	10.8	15.0	5.7	15.0	13.4	13.4	33.6	26.8	10.9	146
2.	185	23.3	15.7	6.5	6.5	13.5	6.5	16.7	34.0	11.9	21.6	13.5	10.8	18.4	8.1	17.8	15.2	13.0	34.6	21.6	12.4	139
3.	180	26.1	18.4	8.9	6.7	15.0	8.9	20.0	34.0	12.2	26.2	14.4	12.2	18.3	8.9	18.8	15.0	13.9	32.8	20.0	12.8	
4.	190	28.4	20.0	8.5	8.9	17.3	7.5	20.0	31.3	10.5	22.6	16.8	10.5	15.8	7.4	18.4	15.8	13.2	27.0	20.0	10.0	
5.	190	24.2	16.8	6.3	6.8	12.6	6.3	16.8	44.0	13.7	21.6	16.8	12.6	16.8	7.9	15.8	13.2	14.2	29.0	21.0	11.6	
6.	165	24.2	15.7	6.6	6.7	13.3	6.7	17.6	37.0	13.3	23.6	16.4	10.3	16.4	6.1	16.4	13.3	14.5	29.0	24.2	10.3	
7.	155	24.5	14.8	6.5	5.8	13.5	6.5	18.0	32.1	12.3	22.6	15.5	10.9	14.8	6.4	14.8	13.5	14.2	35.4	24.5	10.3	
8.	157	24.8	16.5	5.7	7.0	14.0	7.0	17.8	35.0	13.4	25.4	13.4	11.4	17.2	5.7	13.5	12.7	14.6	35.0	20.4	10.2	
9.	178	23.6	15.7	5.6	6.7	12.9	6.7	17.4	33.4	10.7	21.4	12.9	11.2	15.7	6.7	16.9	12.3	14.6	29.2	19.1	11.2	
10.	155	24.5	14.7	5.8	5.8	12.9	7.1	16.8	32.1	11.0	20.0	16.1	10.9	16.1	5.8	17.4	11.6	12.9	35.4	19.4	10.3	
11.	155	24.5	15.5	5.8	5.8	12.9	7.1	16.8	34.1	12.2	22.6	16.1	10.3	16.1	5.2	17.4	13.5	14.2	32.2	20.0	9.7	
12.	338	22.5	15.9	6.2	7.2	12.1	4.7	14.5	31.0	13.0	23.7	16.3	10.0	14.2	7.4	14.5	13.0	12.1	35.2	23.1	11.0	136
13.	216	24.5	15.8	6.0	7.4	13.8	5.5	16.2	34.2	13.9	26.0	17.6	12.0	13.4	7.4	14.8	13.4	14.4	33.3	21.2	10.6	159

Appendix. Table 25 (2)

14.	196	26.0	17.3	6.6	7.6	15.8	6.1	17.8	35.7	14.3	26.0	16.3	11.2	15.3	7.7	16.3	13.8	14.8	33.2	22.4	11.7	
15.	208	25.5	16.5	5.8	7.2	13.9	5.3	17.3	32.8	13.5	23.0	14.4	11.0	15.4	7.2	16.8	13.5	15.8	33.2	21.6	11.0	147
16.	206	26.2	17.0	8.2	8.7	16.0	5.8	18.3	36.4	12.5	21.8	15.5	10.7	14.0	7.3	18.4	13.6	16.5	30.8	21.4	10.2	124
17.	206	23.8	15.5	7.3	7.3	14.0	5.8	18.3	34.0	11.7	22.8	15.5	10.2	14.0	6.3	16.5	15.7	15.5	32.0	22.8	10.2	160
18.	178	25.8	16.8	7.8	7.9	14.6	5.6	16.8	32.0	12.3	24.7	16.9	11.2	15.2	8.4	18.0	16.0	15.8	31.4	17.2	9.6	134
19.	175	23.4	15.5	5.6	8.0	14.3	5.7	16.5	35.4	11.5	24.0	16.0	10.8	13.7	5.7	17.2	13.2	16.0	33.6	22.2	9.7	147
20.	190	23.2	15.3	5.2	7.3	12.1	5.3	15.2	32.1	12.6	24.7	14.7	10.5	13.7	6.3	16.4	13.7	14.7	33.6	24.6	9.5	136
21.	165	24.2	16.4	6.0	7.3	13.9	6.0	17.0	33.2	11.5	23.0	15.2	10.9	15.1	6.1	17.6	13.9	15.2	33.4	24.2	9.7	130
22.	180	23.3	15.0	5.0	6.7	12.2	6.1	15.5	35.0	10.6	22.8	13.9	10.0	13.9	5.6	16.7	13.9	12.8	31.6	23.3	9.5	152
23.	198	20.7	13.3	5.0	6.9	11.6	5.0	14.2	29.9	9.6	20.8	12.1	9.1	13.1	4.1	14.1	12.1	10.1	28.8	21.8	7.6	148
24.	185	21.1	13.5	5.4	5.9	11.3	5.4	14.6	31.2	9.7	21.0	13.0	9.9	13.5	4.6	15.1	11.9	11.9	30.8	20.0	8.1	163
25.	175	24.6	16.6	6.8	6.7	13.1	5.7	15.4	33.6	12.0	24.0	14.8	10.8	16.0	5.7	15.4	12.0	14.3	32.0	23.4	9.7	154
26.	163	23.4	15.3	6.7	6.1	12.9	6.8	16.0	35.0	12.3	23.3	14.7	11.0	16.5	6.1	16.5	13.4	15.3	31.9	23.9	10.4	150
27.	173	24.8	16.8	6.4	6.3	13.9	5.8	15.1	35.8	12.1	25.4	14.5	9.8	14.5	5.8	17.3	14.4	14.4	31.2	22.5	9.8	136
28.	147	25.8	17.7	5.6	6.1	14.3	6.1	17.0	33.6	12.9	25.8	15.6	10.9	17.0	6.8	17.6	15.6	14.9	28.6	21.8	10.2	135
29.	160	23.0	16.1	6.2	6.5	14.2	6.5	15.5	35.8	11.3	24.4	14.9	10.1	16.7	7.1	17.2	13.7	13.7	32.7	21.4	9.5	136

Appendix. Table 25 (3)

30.	152	25.6	17.8	5.6	7.2	15.1	6.4	18.4	33.0	11.9	23.6	14.3	11.2	17.7	7.2	18.4	16.4	15.8	32.2	24.3	10.5	143
31.	175	23.2	16.0	6.2	6.8	14.3	6.3	16.0	33.6	12.0	24.0	15.4	10.3	15.4	6.3	17.2	14.3	14.8	33.2	22.8	10.6	152
32.	170	23.3	15.9	6.3	6.5	13.5	6.5	16.5	34.8	11.2	24.7	15.3	10.0	14.1	5.9	16.4	14.1	13.5	33.0	22.4	9.4	127
33.	150	23.1	16.0	6.0	6.0	14.0	7.3	17.3	35.4	12.0	23.3	16.0	10.7	13.3	6.0	18.0	15.3	15.3	32.6	24.6	10.0	137
34.	153	22.9	16.3	5.9	5.9	13.1	7.2	17.0	35.4	11.8	24.9	15.7	10.5	13.7	5.9	17.6	13.4	13.7	35.2	25.5	10.4	150
35.	175	22.8	14.9	6.3	6.9	13.7	6.3	16.0	32.6	11.4	22.9	14.8	10.3	14.8	6.3	17.2	13.7	13.7	32.6	22.3	9.7	148
36.	145	24.1	15.8	6.2	6.9	13.8	6.2	16.6	34.6	12.4	26.2	16.5	11.0	14.5	6.2	16.5	14.5	13.8	33.0	25.5	9.7	150
37.	140	23.6	15.0	5.0	5.7	12.8	5.7	16.4	32.2	11.4	22.8	14.3	10.7	14.3	5.7	16.4	13.6	12.8	30.8	22.8	9.3	137
38.	183	23.6	15.3	7.1	7.1	13.6	6.5	16.4	34.0	10.9	23.0	15.8	9.9	17.5	8.2	17.5	14.8	16.4	35.6	21.8	11.5	159
39.	175	24.0	17.1	8.0	7.4	15.4	6.8	17.1	35.4	11.4	24.0	17.2	10.3	15.4	6.9	17.7	14.3	14.3	34.3	22.8	10.6	148
40.	132	23.5	14.4	5.3	6.1	13.6	6.2	17.4	31.9	9.1	22.0	16.6	9.1	16.6	6.0	17.4	13.6	13.6	30.4	22.7	10.6	143
41.	185	26.0	17.3	7.6	7.6	16.2	6.5	18.4	35.2	11.8	24.9	15.7	9.7	16.2	6.5	17.3	15.1	14.6	33.4	22.2	9.7	150
42.	168	25.0	16.1	7.7	6.5	14.3	6.5	17.3	35.8	10.7	22.6	16.0	9.5	14.9	5.9	17.9	14.8	14.9	32.2	20.8	10.7	153
43.	170	26.4	17.1	6.5	6.5	15.3	7.0	18.8	35.4	10.0	24.7	15.9	10.0	14.7	7.6	17.7	15.9	15.3	31.2	20.6	11.1	143
44.	173	24.3	16.8	6.4	6.6	15.0	6.9	17.3	34.2	9.8	23.2	14.4	8.7	16.2	7.5	17.3	15.6	13.8	32.4	22.0	9.8	145
45.	160	26.2	18.1	6.9	6.9	14.4	6.3	18.1	36.8	10.6	25.0	15.6	9.4	16.8	8.1	18.7	16.9	15.6	31.2	21.8	11.2	137

Appendix. Table 25 (4)

46.	158	23.4	15.8	6.3	6.3	13.3	7.6	15.8	37.2	10.7	22.2	16.5	8.9	15.8	6.3	17.7	15.8	13.9	32.9	22.1	10.8	153
47.	185	24.3	16.2	7.0	6.5	15.1	6.5	17.3	37.4	11.8	23.8	16.2	8.6	15.7	5.4	17.8	13.0	14.1	31.4	22.2	10.8	141
48.	188	22.9	15.9	5.8	6.4	12.8	6.4	16.0	36.7	11.6	23.4	16.5	8.5	15.9	5.3	17.5	14.4	15.4	31.0	23.9	10.1	145
49.	163	26.4	17.2	6.7	7.4	14.1	7.3	18.4	40.0	10.4	25.2	16.5	9.8	15.3	6.7	18.4	15.3	14.7	32.0	23.0	10.4	141
50.	183	23.2	16.4	6.6	7.1	14.7	7.1	16.9	36.6	11.5	23.5	16.9	9.8	14.7	6.0	18.5	15.3	13.7	32.8	20.8	10.9	128
51.	173	24.2	15.0	6.3	6.5	14.5	7.5	16.2	38.2	9.8	24.8	17.3	9.3	14.4	5.8	17.3	15.0	15.0	31.2	22.0	11.0	137
52.	165	23.6	15.2	6.6	6.7	12.7	7.2	16.4	35.7	10.3	23.0	15.8	8.5	13.9	5.4	18.2	15.7	15.2	32.7	23.0	10.2	150
53.	170	24.1	15.3	6.5	6.5	13.5	7.0	15.9	35.4	10.6	22.9	15.3	9.4	14.7	5.3	17.6	15.3	14.1	31.8	23.5	8.8	138
54.	201	25.9	16.9	7.5	7.0	15.4	6.5	15.9	37.2	10.9	23.4	16.4	10.0	14.9	7.0	17.9	14.8	15.9	32.8	24.4	10.0	135
55.	191	25.6	16.8	7.3	7.3	14.1	6.3	16.2	35.2	11.5	24.1	15.7	9.4	13.1	6.8	17.3	15.7	15.7	30.8	20.4	11.5	128
56.	168	25.6	15.5	7.2	6.5	14.3	6.5	15.5	35.8	10.7	23.2	16.0	9.0	15.5	7.7	17.9	15.5	13.7	31.0	20.8	10.7	142
57.	158	24.1	15.8	6.3	6.3	13.9	6.3	15.8	36.8	10.8	24.0	16.5	9.5	15.8	7.0	19.0	15.8	14.5	33.0	23.4	10.8	151
58.	147	24.4	14.9	6.1	6.8	13.6	6.1	17.0	35.4	9.5	23.8	19.0	8.7	16.3	6.1	17.0	13.6	12.2	30.0	23.8	10.2	---
59.	163	25.1	16.0	6.7	7.3	14.7	7.4	15.3	36.8	9.8	24.0	16.5	8.0	16.5	6.1	17.8	15.3	14.7	32.0	23.3	11.0	125
60.	180	23.3	16.1	6.7	6.6	12.8	6.6	14.4	33.4	10.5	21.6	16.6	8.4	17.7	6.1	16.1	13.9	12.8	29.0	21.0	11.1	125
61.	150	24.0	14.0	6.7	6.0	13.4	6.7	16.0	35.3	10.7	22.6	17.3	8.0	14.0	4.7	16.0	13.4	13.3	32.0	22.0	9.3	141

Appendix. Table 25 (5)

62.	147	22.4	14.2	6.8	6.1	13.6	6.8	16.3	36.0	10.2	23.1	17.7	7.5	16.3	5.5	14.9	13.6	12.9	31.2	21.0	10.2	135
63.	180	23.4	16.1	6.1	6.1	15.0	6.1	16.7	37.2	10.5	23.3	16.1	8.4	14.4	6.1	17.8	14.4	13.9	31.6	20.0	9.5	122
64.	145	25.5	15.8	6.9	6.9	14.5	6.9	18.6	35.9	11.0	23.4	18.5	9.0	14.5	5.4	17.2	14.5	15.2	28.2	25.5	10.3	118
65.	178	23.0	16.8	6.2	6.2	14.0	6.2	16.9	34.2	10.1	22.5	17.4	7.9	15.1	3.9	16.8	14.0	12.9	30.4	20.8	9.6	140
66.	175	22.9	16.0	5.7	6.3	13.1	6.5	16.5	33.0	10.3	22.9	18.3	8.0	16.0	5.7	17.2	13.2	13.7	33.6	23.4	9.7	156
67.	193	22.3	16.0	5.7	6.2	14.0	6.2	16.6	36.9	10.4	24.8	18.1	8.3	15.6	6.2	16.6	12.4	15.0	30.6	23.3	10.4	126
68.	203	22.2	15.8	5.9	5.9	13.3	5.9	15.8	35.4	10.4	24.2	17.2	8.9	15.7	4.3	12.4	14.3	14.8	30.6	24.6	9.9	131
69.	140	23.6	17.8	7.1	6.4	14.3	6.4	17.8	36.4	12.8	26.4	17.2	9.3	17.1	7.8	17.8	16.4	14.3	33.6	22.8	12.8	142
70.	191	24.0	17.8	5.8	6.3	14.6	5.8	16.8	36.7	10.5	23.6	16.2	7.4	17.8	6.3	17.3	14.7	12.0	30.8	23.6	10.5	137
71.	183	23.0	16.4	6.0	6.5	13.7	6.5	16.4	35.6	10.9	20.8	16.4	7.7	16.4	5.5	17.5	14.7	13.1	32.2	22.4	9.3	145
72.	175	20.6	15.4	613	5.7	12.6	6.3	16.0	34.2	9.7	21.1	16.0	6.9	16.0	6.3	16.6	14.3	13.1	31.4	21.7	9.2	135
73.	186	24.6	16.7	6.4	6.4	15.0	5.9	17.2	33.4	10.2	24.2	17.2	7.6	16.1	6.5	17.2	14.5	13.4	30.6	20.4	10.6	146
74.	157	21.6	15.9	6.4	6.4	14.6	6.4	17.8	33.1	10.2	22.3	18.5	8.3	15.9	5.7	17.8	14.6	14.0	33.1	23.6	10.8	160
75.	175	22.8	16.5	6.3	6.8	13.7	5.7	16.5	34.2	9.7	22.8	17.7	8.0	14.9	6.3	13.2	14.3	13.7	29.6	22.8	10.6	138
76.	163	24.5	17.2	6.4	7.3	14.1	5.1	17.8	33.8	11.6	22.7	17.8	8.6	15.3	6.7	17.8	15.9	15.3	30.7	20.3	10.4	140
77.	152	22.4	16.5	6.5	7.2	14.5	6.6	18.4	36.2	10.5	24.3	18.4	9.2	16.4	6.7	17.7	15.8	13.2	30.8	23.6	10.5	147

Appendix. Table 25 (6)

78.	170	22.3	14.7	5.9	6.5	13.0	5.9	17.0	34.2	9.4	23.0	18.2	8.3	15.3	6.5	17.1	13.5	14.1	31.8	21.2	10.0	134
79.	175	21.8	14.3	5.7	6.3	12.6	6.3	16.5	33.2	9.7	23.4	17.1	8.0	14.3	6.9	16.0	14.3	13.1	32.0	22.9	9.7	156
80.	147	23.1	14.3	5.0	6.8	13.6	6.1	19.0	34.0	9.5	23.1	16.3	8.9	15.6	6.8	17.0	13.6	13.6	30.6	23.8	9.5	141
81.	170	23.6	15.8	6.5	6.5	14.1	6.5	17.0	36.4	10.0	23.7	16.5	8.8	15.3	5.9	18.2	14.6	12.9	30.0	23.5	11.2	140
82.	160	23.8	15.6	7.5	6.9	12.5	6.2	18.1	33.8	10.0	22.4	18.1	8.8	15.6	6.9	16.9	13.7	10.6	27.5	21.8	9.4	129
83.	163	22.1	15.3	6.1	6.1	12.3	6.1	17.2	34.4	10.4	22.1	16.5	8.6	15.9	5.1	19.6	14.6	12.2	30.0	22.0	9.8	143
84.	158	25.3	16.5	6.3	7.0	13.7	6.3	17.8	34.2	10.7	22.8	17.7	8.9	17.1	7.6	19.6	14.6	13.9	31.6	23.4	10.8	125
85.	193	24.4	15.6	7.3	6.7	15.6	6.2	17.6	32.2	10.3	23.3	16.6	8.3	16.6	6.2	16.5	14.0	11.9	32.2	20.7	10.4	130
86.	180	25.0	16.1	7.2	6.7	14.4	6.7	17.8	33.4	10.5	23.3	16.7	8.4	17.2	7.2	17.8	14.4	13.9	28.9	22.2	10.0	137
87.	170	23.5	14.6	5.9	7.1	12.9	6.5	17.0	34.2	12.1	24.7	17.0	8.9	15.9	5.9	16.5	15.3	12.9	30.6	23.6	10.0	129
88.	155	23.2	14.8	6.5	7.1	13.5	7.1	18.0	32.8	10.3	22.6	17.4	8.4	16.8	6.5	18.0	14.2	14.2	32.2	21.4	9.7	125
89.	188	22.9	14.9	5.9	5.9	13.3	6.9	15.4	33.5	10.1	23.4	17.0	8.5	14.9	5.3	18.0	13.8	13.8	32.4	24.5	9.1	150
90.	160	24.4	14.4	5.6	6.9	13.1	7.5	17.5	33.8	10.6	22.4	17.5	8.1	13.8	5.0	17.5	13.7	13.7	31.2	21.8	8.8	151
91.	148	21.6	14.9	6.1	6.1	13.5	6.7	16.9	31.8	10.1	20.3	15.5	8.1	14.2	4.7	17.6	12.8	12.2	30.4	23.0	8.8	135
92.	173	24.8	16.8	6.9	6.4	12.7	6.9	16.2	34.7	9.9	20.2	17.2	9.9	13.3	6.4	16.2	14.5	13.3	35.2	22.0	10.4	150

Appendix. Table 25 (7)

93.	142	22.5	16.2	6.3	7.0	13.4	7.0	16.2	41.5	9.9	24.6	17.6	10.6	14.1	7.0	15.5	14.8	14.0	33.8	22.6	11.2	140
94.	145	22.1	15.2	6.2	6.9	13.8	6.9	16.5	37.2	9.6	23.4	18.6	11.0	15.2	5.5	17.2	15.2	13.8	32.4	22.8	11.0	140
95.	168	22.6	16.1	6.0	6.0	13.7	5.9	16.0	32.8	9.5	20.8	17.8	9.6	13.1	6.0	14.9	13.7	13.7	32.2	21.5	10.7	155
96.	145	24.1	15.2	6.2	6.9	13.8	6.9	16.5	36.4	10.3	24.1	15.2	10.3	14.5	6.2	15.9	14.5	14.5	31.0	24.8	11.0	152
97.	148	23.6	15.5	6.1	6.7	12.2	6.7	16.2	31.8	10.1	22.2	16.6	10.8	14.2	6.7	14.2	14.2	13.5	35.0	22.3	11.5	125
98.	163	25.2	18.4	6.8	6.7	12.9	6.1	17.8	35.6	11.0	20.9	15.3	11.6	14.7	6.8	17.8	15.3	15.9	36.8	21.4	11.1	120
99.	168	24.4	17.8	6.6	6.6	14.9	5.9	17.3	34.6	10.7	22.6	16.7	11.3	14.8	7.7	17.9	15.5	16.7	34.0	23.0	11.6	122
100.	165	22.4	15.7	4.8	6.1	12.7	6.0	17.0	31.5	10.3	23.0	16.4	10.9	15.1	7.9	15.1	12.7	14.0	34.6	21.8	10.8	129
101.	168	25.0	16.1	5.4	5.5	14.3	5.9	17.8	33.3	10.7	22.6	17.8	11.3	14.8	7.1	17.9	14.3	13.1	36.9	22.0	10.7	110

See Table 15, page 38, for summary.

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